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12

FoV (10)

4 Moving Byte
Code structures

7A

FoV Limits

6A

7B

3

B

2

8

5

FIG 1A

1

folding mirror

7A

8 (optical Bench)

299

10

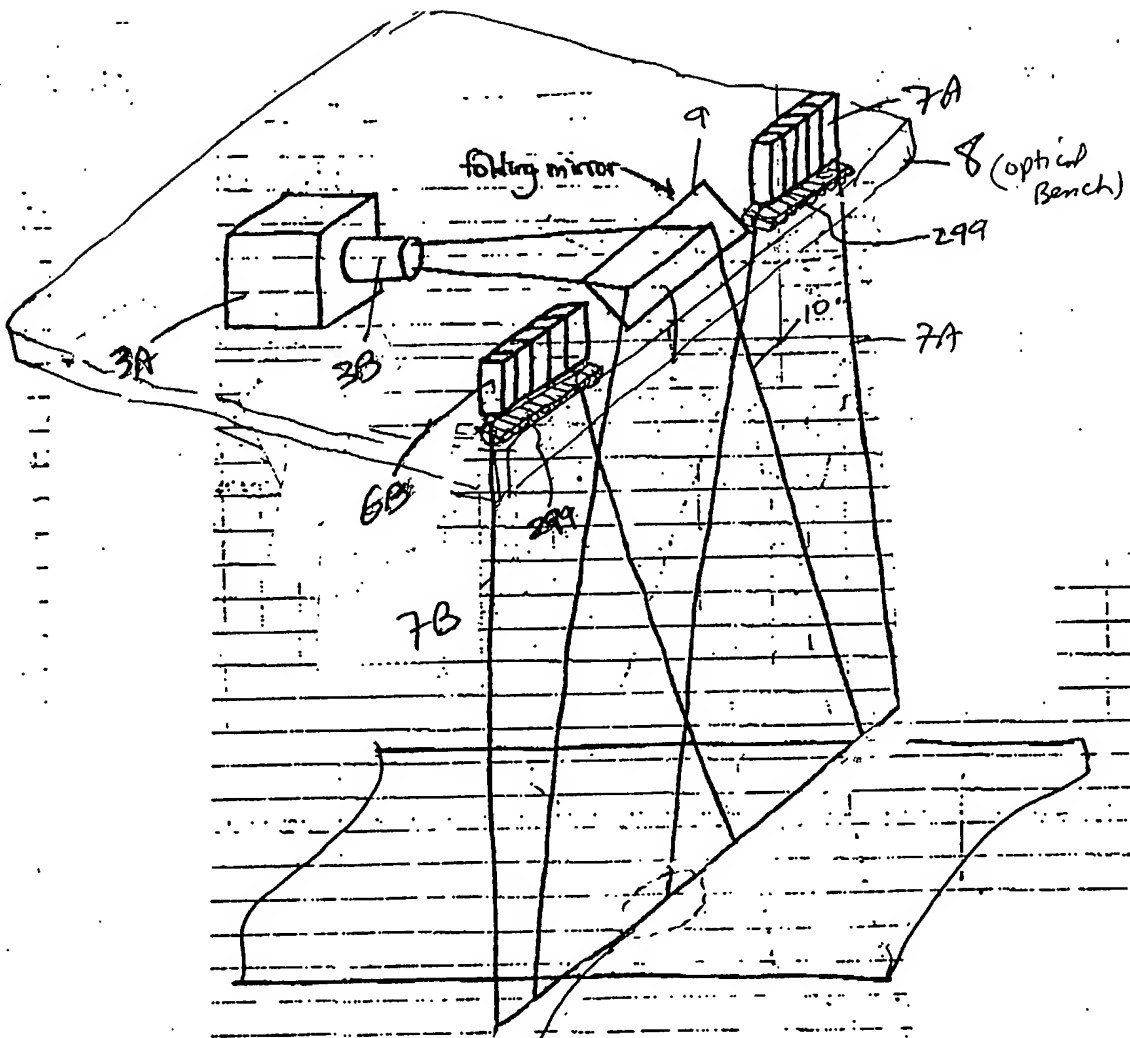7A

3A

3B

9

6B

299

7B

FIG. 1B1

1A

magnified Field of View of
CCD sensor element on
object

width of projected
Planer laser illumination
Beam on
object

FIG 1B3

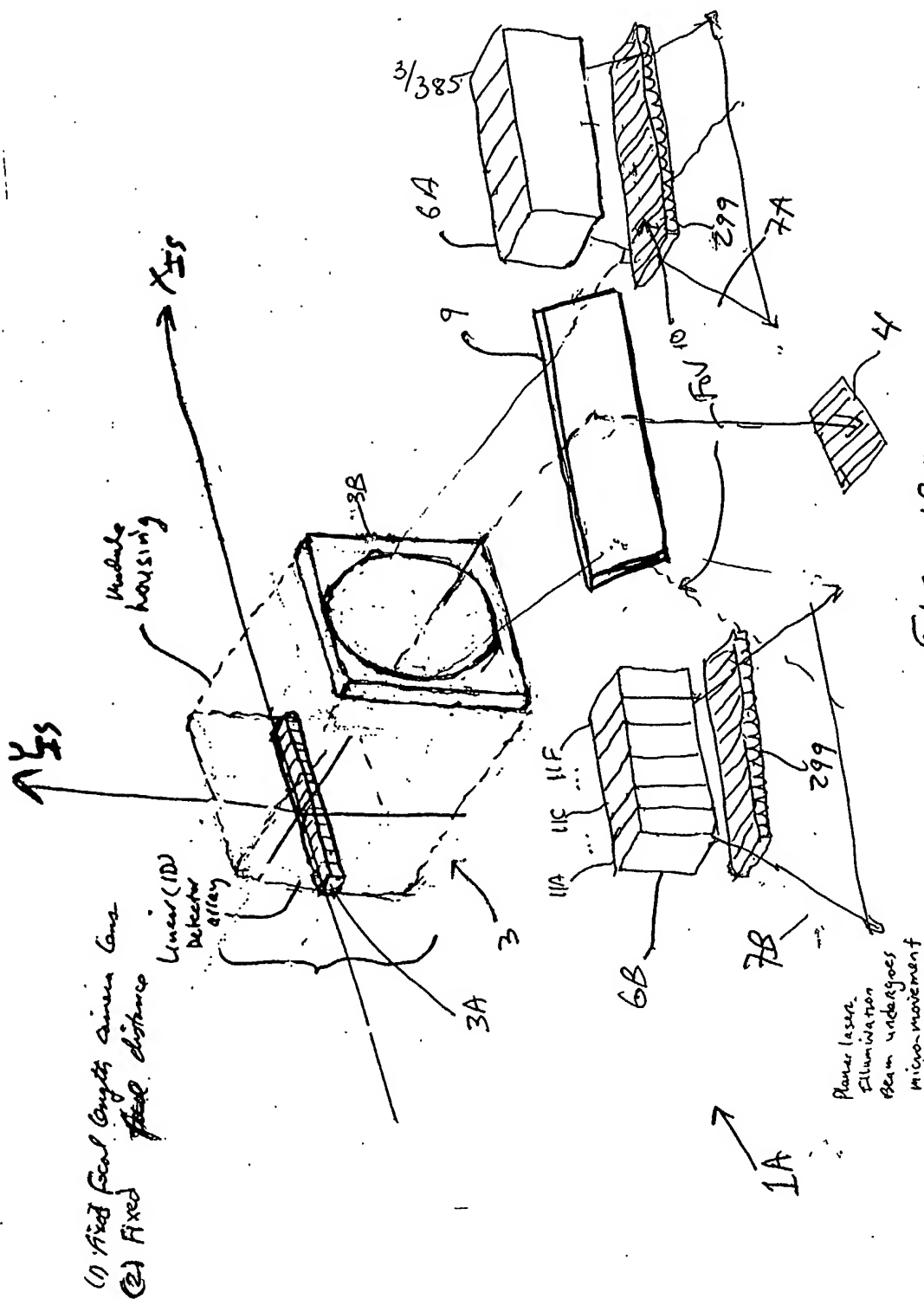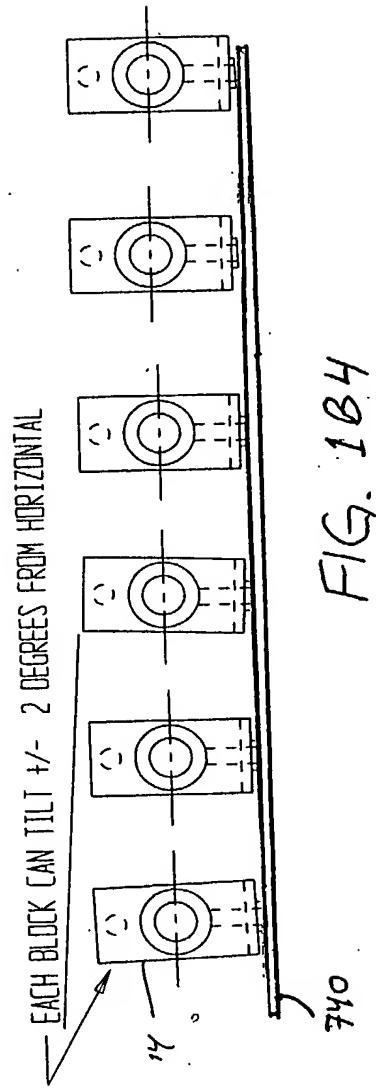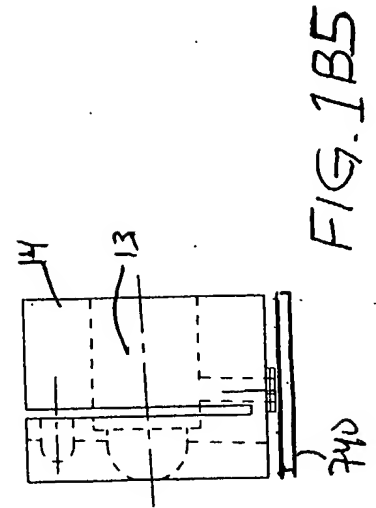(1) Fixed Focal Length Imaging Lens
(2) Fixed Focal distance

Module housing

Linear (1D) detector array

3B

3A

3

1A

Planar laser Illumination Beam undergoes micro-movement

6A

3/385

7A

6

9

4

6B

7B

11A
11B
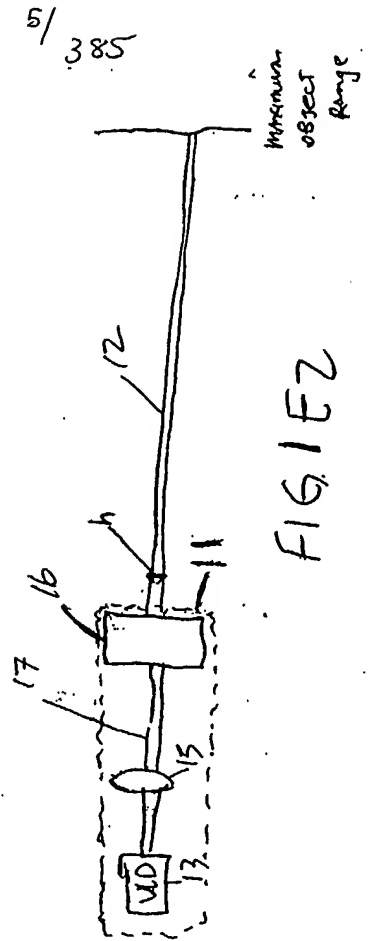11C
11D

FIG. 1B2

EACH BLOCK CAN TILT +/- 2 DEGREES FROM HORIZONTAL

FIG. 18A

VLD BLOCK CAN PITCH FOWARD FOR ALIGNMENT WITH OTHER VLD BEAMS

FIG. 18B

FIG. 1C

FIG. 1D

$\pi I(yc) = gaussian$

FIG. 1E1

FIG. 1E2

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FIG.1F

29B

163

28

6B

30B

162

29A

Camera
Control
Computer

10

22

163

21

3

30A

9

164 6A

162

25

164 26

FIG 1G1

FIG. 1G2

FIG.163.

FOV Limits

FOV of a single pixel

FOV Limits

FIG. 164.

FIG. 1G5

FIG. 1G6

26

25

33A

33B

25

26

FIG. 1G7

32A

6A,6B

32B

14

16 13

FIG. 1G 8

L bracket

14B

VLD sticking
out of block

13

32A

2.000"

14
block

32B

cylindrical lens
16

2.000"

FIG. 1G. 9

3.500" 3.275" 2.675" 2.075" 1.475" .875" .575" .000"

16

14B

32A

14

11

13

32B

FIG. 1G10

.750"

.540"

13

1.237" .861"

14

16

FIG. 1G 11

.550"

13

14

16

Ø.394"

FIG. 1G 12

R<0.5% (760—800nm)
over zone Ø4.3
SO/5×0.063;C1×0.4;C1×1.6

R<1% (760—800nm)
over zone Ø4.8
SC/5×0.063;C1×0.4;C1×1.6

Ø4.8 +0.01 / 0

Ø5.5 0 / -0.7

Ø6.5 0 / -0.03

6.5 mm

2.5±0.1

5/R0.5

13

FIG. 1G 13

Testzone Ø4.3

13

FIG. 1G 14

Farthest
Object (i.e.
Working
Distance In
PLIIM-Based
System)

Planar
Laser Illumination
Beam (PLIB)

12

11

16

14B

14B

0.394"

15

14

13

14A

FIG. 1G15A

Farthest
Object (i.e. Working
Distance In
PLIIM-Based
System)

PLIB

≈ 0.6 mm
(0.06 cm)

≈ 1.5 mm
(0.15 cm)

12

16

0.5"

0.394"

14A

15

14

13

≈ 61 in.
(155 cm)

FIG. 1G15B

FIG.1G.16A

FIG.1G16B

PLIM w/
powell lens

FIG. 1G17A

FIG. 1G.17B

FIG. 1G17C

FIG. 1G17D

FIG. 1G17E

FIG. 1G.17F

d = dimension of CCD Pixel

Eccd = CCD irradiance
(in Watts / meter squared)

D

ri

f = Lens Focal Length
F = Lens f-stop
ri = Image distance
ro = Working distance
m = Lens Magnification

Assumptions:
1) Objects are Lambertian Scatterers
2) Object Reflectance = 100%
3) Optical Transmittance = 100%
4) Square CCD pixels

do = dimension of CCD Pixel projected
onto the object plane

ro

Eobj. = Evenly distributed irradiance
(in Watts / meter squared)

CCD-Based Scanner

FIG. 146

FIRST GENERALIZED METHOD
of Reducing Speckle-noise
Patterns AT Image
Detection array of The
IFD Subsystem (3)
(SPMF)

12

FOV(10)

MOVING BAR CODE
STRUCTURE
4

7A

7B

6A

SPMF

2

3

6B

SPMF

8

5

1

FIG. 1I1

FIG. 112A

Prior to object Illumination

The First Generalized Speckle-Noise Pattern Reduction Method
Of The Present Invention

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial phase of the transmitted PLIB along the planar extent thereof according to a spatial phase modulation function (SPMF) so as to

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the power of the speckle-noise pattern observed at the image detection array.

B

FIG. 1I2B

6A →

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305

array #1

array #2

14

16

302

307

300

22

303A,
304B

301B

$f_{osc.} \simeq 20 KHZ$

FIG. 1I3A

301A

301B

FIG. 1I3B

307B

305

307A

306

FIG. 1I3C

304A

303A

$V(\omega t - \pi/2)$

301A

301B

303B

304B

302

FIG. 1I3D

$V(\omega t)$

Target
oBject

Portion of the
cylindrical lens array

P

Δx

D

$$(\Delta x / D) P = \lambda$$

Cylinder Lens

Laser ~ λ

Figure 1

$$\Delta x \gtrsim \frac{\lambda}{P} \cdot D$$

FIG. 1I3E

FIG. 1I3F

FIG 1I3G

311A(HOE)

← 310

6A →

14

16

22

← 315

$f_{osc.} \simeq 20 KHz$

FIG 1I4A

array#1

311A   311B

holographically-fabricated
cylindrical lens array

FIG. 1I4B

array#2

316

318B

FIG 1I4C

318A

dual HOE
array

314A

313A

$\sim V(\omega t - \pi/2)$
A

314B

313B

311A   311B

312

$\sim V(\omega t)$
B

FIG. 1I4D

FIG. 1I5A

FIG. 1I5B

FIG. 1I5C

FIG. 1I5D

340

Beam Deflection
Control Signals
To Acousto-optic
Bragg Cell
Panel

342

341

14

16   345

341

FIG. 1I6A

13

15

340

16

344

345

348B

341

Beam deflection
control signals
To Acousto-optic
Bragg cells

348

347A

347B

346   343

342

FIG. 1I6B

363
360
365
6A,6B
362
361
364
16
367
368
14
Deformable Mirror (DM)
364
22
microoscillation
micro-oscillating Planar Laser Illumination Beam (PLIB)

FIG.1I7A

365
366C
366B
366A
362

FIG.1I7B

365
362
Dm(364)
14
16
368
22

FIG.1I7C

301
385

6A,6B

370

14

16

374
phase modulation
disc

372   371

FIG. 1I8A

PLIA

371

370   6A   m   ω

22   acc   375

374

FIG. 1I8B

370

14
16

375

373

372

374

371

FIG. 1I8C

E-field is sum
of E-field from
each lenslet

Target
object

10-100 mm

374

371

FIG. 118E

PLIB

6"

10A, 6B

376

376

374

FIG. 118D

32/ 385

6A,6B

706

22

701

703

700

702

14

16

705

701

704   703

"Phase-only LED-Based
Phase modulation
Panel"

FIG.1I8F

13

15

6A,6B

16

708
701

705

708

704
703

706

22

FIG.1I8G

6B

380B

382

382

302

383

384

383

384

382

Motor

380A 384

FIG. 117A

optical specifications:

- 30 cylindrical lens (lines) per linear inch
- focal length ≈ 2.0 millimeters
- diameter of lenticular carousel ≈ 4 inches
- acrylic material

FIG. 119B

387

386

385B

384

380

382

384

388C

388C

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FIG. 1I10A

optical specifications

• 30 cylindrical lens (lines) per linear inch

• focal length ≈ 2.0 millimeters

o diameter of lenticular carousel ≈ 4 inches

FIG. 1110B

388B

388A

372C

392A

392B

40E

388D

387

394

388C

392

396

FIG.1IIIA

FIG 1I11B

FIG.111C

FIG. 1I12A

FIG. 1I12B

FIG.1I 12C

FIG.1I 12D

Second (Generalized) Method of
Reducing Speckle-Noise Patterns
at Fringe Detection Array
of the FFD Subsystem (3)

(TIMF)

FOV(10)

MOVING BAR CODE
STRUCTURE

4

12

7A

7B

6A

TIMF

3
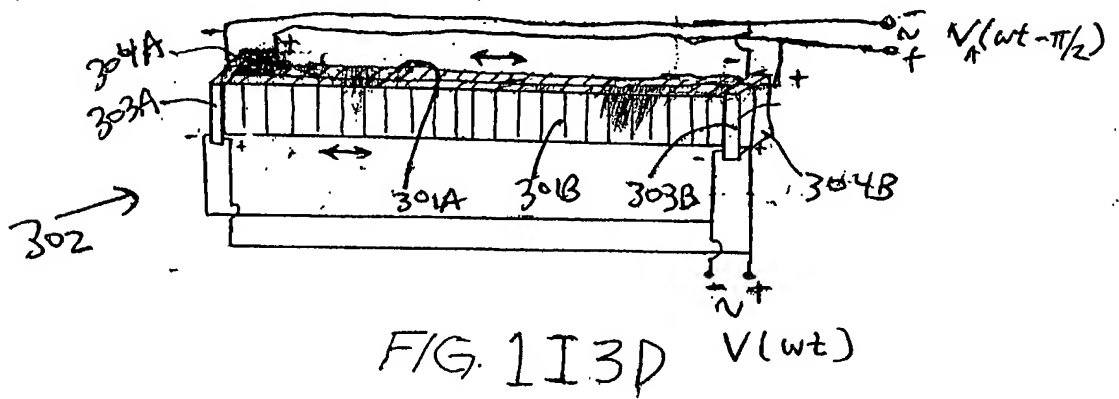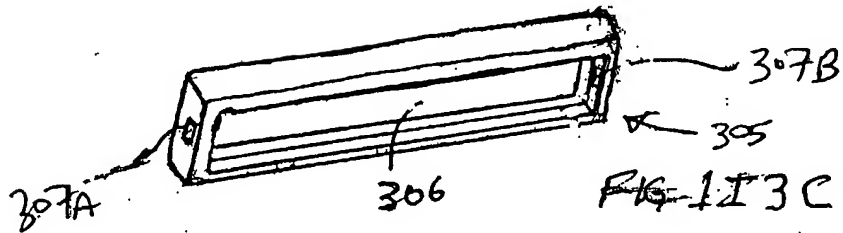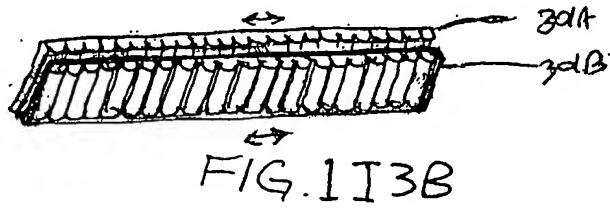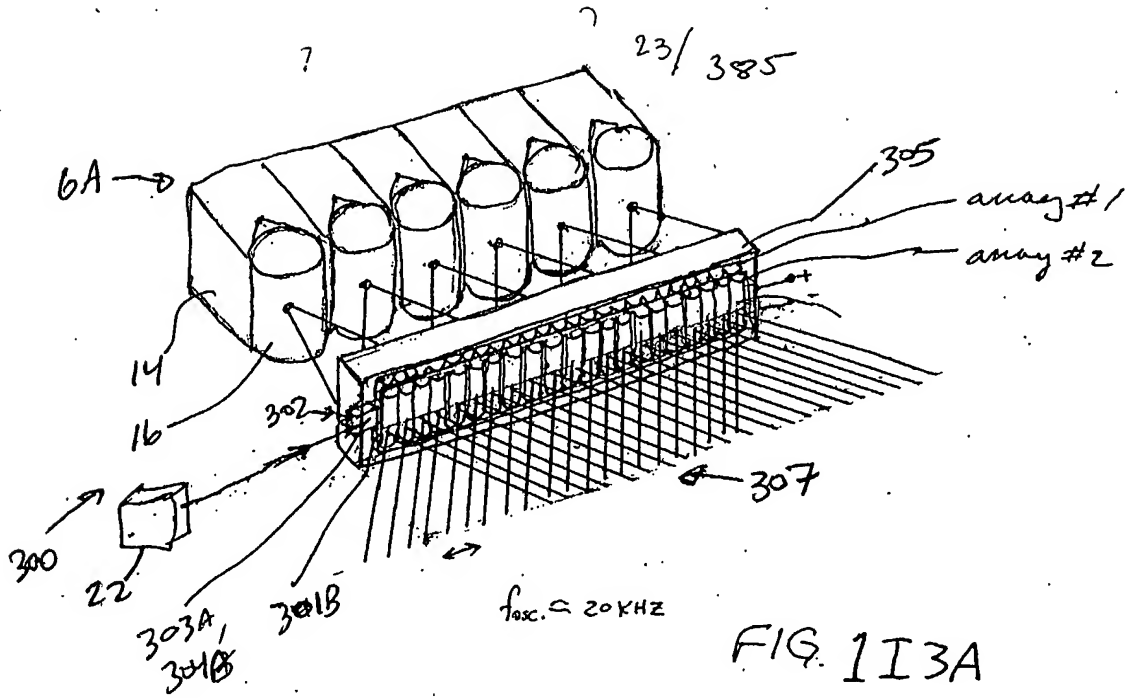
6B

TIMF

2

8

5

1

FIG. 1I13

FIG. 1 I 13A

The Second Generalized Speckle-Noise Pattern Reduction Method
Of The Present Invention

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal intensity of the transmitted PLIB along the planar extent thereof according to a temporal intensity modulation function (TIMF) so as to

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

—A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce power of the speckle-noise pattern observed at the image detection array.

—B

FIG. 1I13B

420

6A,6B

423

421

14

16   423

422

424

425

Temporal
Intensity
modulator

FIG.1I14A

13

15

14

16

420

optical
switching
Control
Signals

423

422

424

27

421

425

26

FIG.1I14B

461. 385

TIM
Controller
447

22

13'

Temporal
Intensity
Modulation
Control
Signals

14

16

442

441

443

441

Mode-Locked Laser Diode
(MLLD) array

FIG. 1I15A

447

22

$$L$$

$$f_{MLB} = c/2L$$

444

445

Multimode
Diode laser cavity
$(InGaAs\beta)$ D7

Collimating Lenslet

Active
mode locker 446

(Temporal
Intensity
modulator)

13'

448
Passive Mode locker
(saturable absorber)

449
Mirror

FIG. 1I15B

385

Temporal
Intensity
Modulation
Control
Signals

FIG. 1I 15C

FIG. 1I 15D

761
(TIM controller)

i_{VLD}
i_{MAX}

(milliamperes)

0

t

FIG. 1I15E

(VLD)
Intensity

MAX

0

t

FIG. 1I15F.

Third Generalized Method of
Reducing Speckle-Noise Patterns
at Image Detection Array
of the FFO Subsystem (3)

(IPMF)

FOV(10)

MOVING BAR CODE
STRUCTURE
4

12

7A

7B

6A

6B

2

3

IPMF

IPMF

8

5

1

FIG. 1I16

FIG. 1 I 16A

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Third Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal *phase* of the transmitted PLIB along-the planar-extent-thereof according to a *Temporal phase* modulation function (TPMF) so as to:

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

—A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce power of the speckle-noise pattern observed at the image detection array.
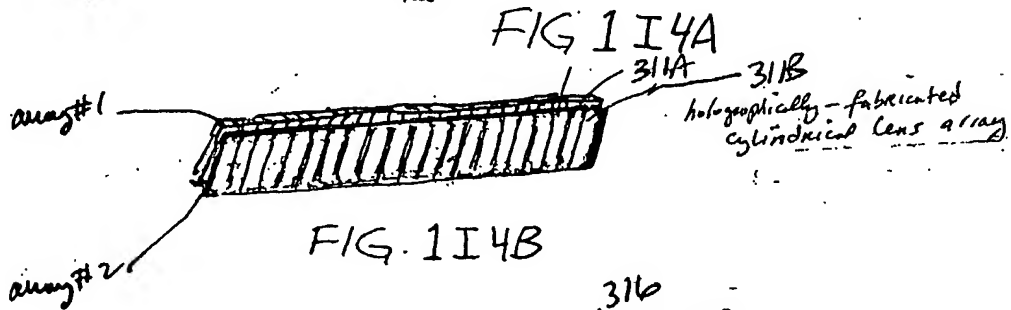
—B

FIG. 1I 16B

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etalon structure

6A,6B

430

432

431

433

14

16

435

437

FIG. 1I17A

6A,6B

13

436A

433

437

15

436B

14

16

434

432

431

435

FIG. 1I17B

6A, 6B — 706 — 701 — 22 — 800 — 703 — 702 — 14 — 16 — 705 — 701 — 704 — 703

"Phase-only LCD-Based phase modulation Panel"

FIG. 1I17C (Δφ > coherence length) of VLD

6A, 6B — fiber-optical array (811) — 702 — 810 — 14 — 16 — 812 — 704 703

FIG. 1I17D

810 — 13 — 15 — 6A, 6B — 16 — 702 — fiber optical array (811) — 812 — 704 — 703

FIG. 1 I17E

Fourth Generalized Method of
Reducing Speckle-noise Patterns
at Fringe Detection Array
of the IFD Subsystem (3)

(TFMP)

12

FOV(10)

MOVING BAR CODE
STRUCTURE
4

7A

7B

6A

2

3

6B

8

5

1

FIG. 1I18

FIG. 1 I 18A

Fourth Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal _frequency_ of the transmitted PLIB according to a temporal intensity modulation function (T MF) so as to

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

— A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce power of the speckle-noise pattern observed at the image detection array.

— B

FIG. 1I 18B

FIG. 1I19A

FIG. 1I19B

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multi-mode diodes

13

15

456

14

16

452

451

FIG 1II19C

FIG. 13 GENERALIZED METHOD
of Reducing Speckle-noise
Patterns AT Image
Detection array of the
IPD Subsystem (3)

(SI'MF)

FOV(10)

12

MOVING BAR CODE
STRUCTURE
4

7A

7B

6A

2

3

5

6B

8

1

FIGURE 20

FIG. 1 20A

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Fifth Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the transmitted PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to .

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce power of the speckle-noise pattern observed at the image detection array.

B

FIG. 1I20B

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FIG. 1 I 21A

FIG. 1 I 21B

spatial intensity
modulation screens

FIG. 1 I 21C

$V(\omega t - \pi/2)$

$V(\omega t)$

FIG. 1 I 21D

Generalized Method of
Reducing Speckle-Noise Patterns
at Image Detection array
of the IFD Subsystem
(SIMF)

12

FOV(10)

MOVING BAR CODE
STRUCTURE
4

7A

7B

6A

6B

3

SIMF

2

8

5

1

FIG. 1I 22

FIG. 1I 22A

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Sixth Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

After illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to :

A

produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array.

B

FIG. 1I 22B

Electro-optical
Rotating
IRIS

460

3A

module
housing

3A'

3B1

3B2

LCD
Drive
CICs

464

6A

299

optical
axis

SIMF 461

463 460

462

6B

299

4

FIG.1I 23A

Mechanically — Rotating
IRIS

3A

module
housing

473

474

476

3B1

3B2

motor
Driver

478

6A

299

optical
axis

SIMF 472

477

473

471

6B

299

4

470

FIG.1I 23B

Seventh Generalized method of
Reducing Speckle-Noise Patterns
at Image Detection Array
of the IPD Subsystem

(TIMF)

FOV(10)

MOVING BAR CODE
STRUCTURE
4

12

7A

7B

6A

2

3

TBmP

6B

8

5

1

FIG.1I24
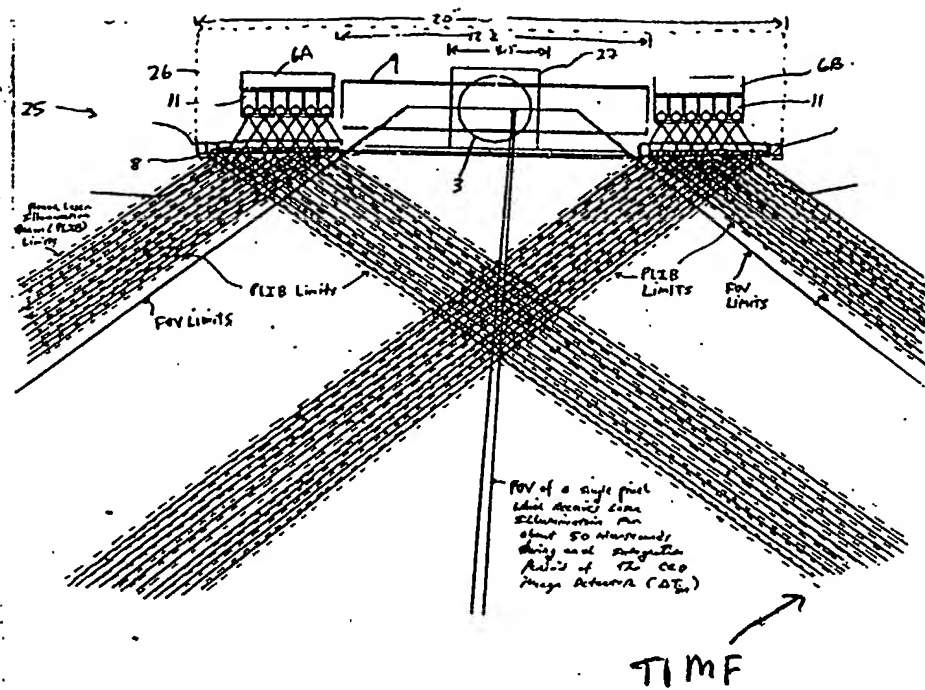
FIG. 1I 24A

Seventh Generalized Speckle-Noise Pattern Reduction Method
Of The Present Invention

After illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a temporal intensity modulation function (TIMF) so as to .

. produce many substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

— A

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array.

— B

FIG. 1I24B

299

6A

optical axis

module housing

381
382
341

34

4

TEMP Control Signal

electro-optical
temporal intensity
modulator (EOM - PMC)

481

299

6B

480

(1)variable focal length lens
(2) variable focal distance

FIG. 1Z4C

EIGHT GENERALIZED METHOD OF REDUCING THE SPECKLE PATTERN NOISE OBSERVED IN PLIIM-BASED IMAGING SYSTEMS

A —
Use a PLIIM-BASED Imager to produce a series of consecutively captured digital images of an object over a series of photo-integration time periods of the PLIIM-Based Imager, wherein each digital image of the object includes a substantially different speckle noise pattern produced by natural oscillatory micro-motion and/or forced oscillatory micro-movementof the Imager relative to the object during operation of the PLIIM-Based Imager.

B —
Store the series of consecutively captured digital images of the object in buffer memory within the PLIIM-Based Imager.

C —
Add relatively small (e.g. 3x3) windowed image processing filters to the additively combine and average the pixel data in the series of consecutively captured digital images so as to produce a reconstructed digital image having a speckle noise pattern with reduced RMS power.

FIG. 1124D

manual
sweeping
Action
across code Symbol
or
graphical indicia

FIG. II24E

image captured during photointegration time period ΔT_{k+1}

image captured during ΔT_{k+2}

image captured during ΔT_{k+3}

image captured during ΔT_{k+4}

image captured during ΔT_{k+5}

image captured during ΔT_{k+n-1}

image captured during ΔT_{k+n}

Buffered series
of consecutively
captured digital
images with speckle-
pattern Noise

Reconstructed
Linear image
with reduced
Speckle-pattern Noise

pixel data
subset in reconstructed image
derived

Case: Linear images

FIG. 1I24F

FIG. 1I24G

j — image captured during photo-integration time period DT_{k+1}

— image captured during photo-integration time period DT_{k+2}

j — image captured during photo-integration time period DT_{k+3}

j — image captured during photo-integration time period DT_{k+n}

Reconstructed image with Reduced speckle-noise power

Buffered series of consecutively captured digital images with speckle-pattern noise

Pixel data subset in Reconstructed image derived by weighted averaging of spatially corresponding pixel data subsets of consecutively captured images

Case: 2D area imagen

FIG 1I 24H

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NINTH GENERALIZED METHOD OF REDUCING SPECKLE PATTERN NOISE IN PLIIM-BASED IMAGING SYSTEMS

A
During each photo-integration time period of a PLIIM-Based Imager, produce numerous substantially different spatially-varying speckle noise pattern elements (i.e. speckle noise pattern elements at different points) on each image detection element in the image detection array of the PLIIM-Based Imager.

B
Spatially (and temporally) average said spatially-varying speckle-noise pattern elements over the spatial area of each image detection element, thereby reducing the RMS power of speckle-pattern noise observed in said PLIM-Based Imager.

FIG. 1124I

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FIG. 1I25A1

* Lateral and
Transverse
Microoscillation of PLIB

FIG. 1I25A2

FIG. 1I25B1

FIG. 1I25B2

FIG.1I25C1

* Lateral and
Transverse
Microoscillation of PLIB

FIG.1I25C2

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865A
898
899
896
817

865B
898
899
897
896
862
861
864
863

895

900

900

FOV of a elongated CCD detector element

working distance

FIG. 1 I 25 D1

895

861
898 DM
896
899 FOV
863
862 865B
897
PLIB (800)

FIG. 1 I 25 D2

FIG. 1I25E1

* Lateral and
Transverse
Microoscillation of PLIB
905

FIG. 1I25E2

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FIG. 1I25P1

* Lateral and
Transverse
Microoscillation of PLIB

FIG. 1I25F2

FIG. 1I25G1

* Lateral and
TRANSVERSE
microoscillation of PLIB

FIG.1I25G2

935

861 864 863

865A'

862

937

865B'

937

939

939

936

936

940

940

Maximum
working
distance

Fov of a
enlarged
CMOS
detector
element

* Lateral and
Transverse
Microoscillation of PLIB

FIG. 1I25 H1

935

936

861 938 939

863 940 FOV

862 865B' 937 PLIB

FIG. 1I25 H2

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Lateral and Transverse Microoscillation of PLIB

FIG.1I25I1

FIG.1I25I2

FIG.1I25I3

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861 864 863 955

865A

862 957 optical shutters

865B 958

957 956

956 958 959

959

* hybrid Technique:
· Temporal intensity modulation
· Spatial   modulation
  in Transverse direction

Maximum
Working
distance

FOV of a
magnified
"CCD"
Detector
element

FIG. 1I25J1

955 →

157

865B 958

861 960 959 FOV 961

863

862

PLIB

FIG. 1I25J2

861 864 863 13 ethalon 967 965

862

865A"

967

966

865B"

968

969

966 →

968

969

971

971

971

* Hybrid Technique :
- Temporal Intensity mod.
- spatial phase mod.

Maximum working distance

FOV of a magnified CCD/or Detector element

FIG. 1I25K1

* Transverse Microoscillation of PLIB

965

13 865B" 970 968

863

969 FOV 971

862 ethalon 967

PLIB

FIG. 1I25K2

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FIG. 1I25L1

* hybrid:
  • Temp. freq. mod.
  • spatial phase mod.

*
  Transverse
  microoscillation of PLIB

FIG. 1I25L2

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* hybrid
  · Temp. freq. mod.
  · spatial phase mod.

* Transverse
  Microoscillation of PLIB

FIG. 1I25M1

FIG. 1I25M2

861   864   863

995

865A

862

865B

997

997

998

996

996

999

999

1001

1001

1001

MAXIMUM
WORKING
DISTANCE

FOV of a
magnified
CMOS
detector
element

✶ hybrid:
 · spatial intensity mod.
 · spatial phase

✶ lateral and
  Transverse
  microoscillation of PLIB

FIG. 1I25N1

995

861   865B 1000   997   998

863

862

FOV 1001

PLIB

FIG. 1I25N2

FIG. 1H1

FIG. 1H2

Image distance vs object distance

FIG. 1H3

FIG. 1H4

FIG. 1H5

fixed focal length lens
cases

camera

camera lens

fixed focal length imaging lens

Camera FOV limit

Boxes, etc

scan field

FIG 1K1

Conveyor 34

fixed focal length imaging lens

Scan field

Envelope packages

Conveyor 34

FIG. 1K2

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9B   9D   9E

FOV (of
linear camera,
shown edge on)

9A

3

3B

9C

FIG. 1L1

2Z

3B

35

9G

3   10

FOV

FOV

FIG. 1L2

Pixel power density vs. object distance (general example)

FIG.1M1

Near and far object distance laser power distribution data and curve fit

FIG.1M2

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Planar laser beam width vs. object distance

FIG. 1M3

Figure 4: Planar laser beam height vs. object distance (far object distance focus)

FIG 1M4

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Center line power density vs. object distance (far object distance focus)

FIG. 1N

Figure 6: Pixel power densities vs. object distance

FIG. 10

lateral extent of field of view which must be covered

results of summing contributions from all VLDs

Near Field

Far Field

individual VLD contributions

FIG. 1P1

FIG. 1P2

$100/_{385}$

FIG. 1Q1

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FIG. 1Q2

FIG.1R1

FIG. 1R2

FIG.1S1

FIG.152

Package

Application:
— Botton scanner

FIG 1T

107/385'

FIG. 1U

Plane of Laser illumination

12

FOV(10)

Applications:
o Hand-Held Scanner
o Presentation Scanner

FIG. IVI

FIG. IV2

2-D
region
of
space

FIG.1V3

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Moving
Plane of
Laser
Illumination 12'

12'

Moving (3)

Moving (3)

FIG. 1V4

• Hand-held Scanner
• Projection Scanner

1
21
20
22
19
18   6
289   37A'
6A

4

3B

3A
6B
289
37B'
10

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Moving Bar Code Structure

Stationary Planar Laser Illumination Beam 12

Envelope 10

12

7A

7B

6A

3

6B

8

5

2

40

FIG. 2A

FIG. 2 B1

(1) $f_{(1)}$
(1) - Focal Length/airier lens
(2) - Vertical focal distance

X

6A

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11B

11A

299

optical axis

4

3B

3A

y

3

299

11B

11A

6B

40A

FIG 2B2

FIG. 2C1

- fixed Focal length Imaging lens

- Variable or Dynamic
  Focus Control

3B'

3A1

3A

3D

3C

3'

3E

22

FIG. 2G.2

FIG. 2D1

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Fixed Focal Length/
Variable or
dynamic
Focus Control
2B

9 Stationary

3A

299

12

18 VLD Driver
18 VLD Driver
18 VLD Driver

18 VLD Driver
18 VLD Driver
18 VLD Driver

299
17

Micro-Controller
16A

Micro-Controller
16B

764

764

Image Grabber
17

Camera Control Computer
22

Data Buffer
20

Image Processing Computer
21

3

40B

FIG. 2D2

- fixed focal length imaging lens
- Variable or dynamic focus control

3B'

3A'

3A

3D

3C

3'

3E

22

FIG. 2D3

26A   3'   37A

QB

3B

299

7A

40C

299

37B

0

47A

12

FIG. 2E1

FIG. 2E2

- Fixed focal length imaging lens
- variable or dynamic focus control

FIG. 2E3

FIG. 2FI

Fixed focal length/
variable or dynamic
3B focal control

9

stationary

37A

stationary

299

124/385

stationary

37B

299

3A

VLD Driver

VLD Driver

VLD Driver

8

8

Microcontroller

76A

6A

6B

VLD Driver

VLD Driver

VLD Driver

Microcontroller

76B

19

Camera Control Computer

22

Image Grabber

Data Buffer

20

Image Processing Computer

21

3

40D

FIG 2F2

o Fixed focal length imaging lens

o Variable focus or dynamic focus control

3B

3B'

3A1

3A

3D

3C

3E

3

22

FIG.ZF3

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Top Conveyor Scanner:
- fixed focal length imaging lens
- variable focal distance control

Side Conveyor Scanner:
- fixed focal length imaging lens
- dynamic focal distance control

40

40

FIG. 2G

127/385

Composite
Plane of
Laser
Illumination

FOV

40C
21
20
22
19
18
37A
2
6A
12

21
20
22
18
37B
6B
28A
3A
3B

FIG. 2H

Applications:
• Hand held Scanner
• Presentation Scanner

FIG. 2I1

FoV 10

Stationary Bar Code Symbol

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Moving Plan Laser Illumination Beam 12

3rd Scanning Region

FoV limits

7A

7B

6A

3

6B

2

8

5

40

3-D
Scanning
Region

FIG. 2I2

FIG 2I3

- fixed focal length imaging lens
- variable or dynamic
  focus control

3B'

3A'

3A

3D

3C

3'

3

3E

22

FIG. 2I4

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Plane of laser illumination

FoV limits 20

18' 37A'
6A
27'
18' 9'
19
22 22
40'
20 20
21

12'

3B'

3A'

8B

2q

18' 37B'

FIG. 215

HOST SYSTEM

FIG. 2I6

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velocity

moving bar etc structure.

FOV Limits

12

10

7A

7B

6A

3

6B

8

50

5

2

FIG 3A

6A
3A
3"
3'
6B
299
38"
299
7A
10
50A
7B
belt surface

FIG.3B1

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FIG. 3B2

optical axis

(1) variable focal length zoom lens
(2) variable focus distance

module housing

299
3A
3A'
3B1
3B2
6A
6B
299
4

FIG 3C1

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- variable focal length lens bus
- variable focal distance

variable or dynamic focus control 3B2

3B1 variable focal length (zoom) control 3A1

3A

3G2 3C2

3C1

3E2 3C2

3E1

3D

3''
3

FIG. 3CZ

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motor 43

42

3''

±18mg

3B1
zoom
lens

Stationary
lenses
3A1

3A
(image plane)

object
plane

focal
distance
lens (3B2)

CCD
Image
Detection
array

(image
plane)

±6mm

44

45

FIG. 3D1

412

411

3A1L

46

410

3B''

3A

401B

401

1000

416

404

403

A

414

400

407   401A

413

FIG. 3D2   408

405

3B''

405

415

412

3A1

404

1101

401B

414

416

39
(image
sensor
chip)

401A

403

413

408

406

400

1100

402

407

FIG. 3D3

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1109A   1109B

Linear CCD Sensor
3A

Camera
Board
1101

Heat sinking
structure
1100

1112A   sensor
window   1112B

FIG. 3D4

1105A
1105B

1109A   1109B

1100

1103

1111

1102   1105C   1112B

1112A   1110   1105D

FIG. 3D5

1107

1107

IC chips

IC chips

multi-layer PC Board
(1101)

1108 (socket)

1107   1107

FIG. 3D6

heat sink
structure
(1100)

Release/lt
Sensor.
1109A (1109B)

Camera Body (400)

1101

1110

optical
axis of
camera

Pins (1104)

Thermal
Coupling
interface   Pins (1104)

1112A

Pe package
of linear
CCD Sensor
(3A)

1106

Camera
PC Board
(1101)

Lens group #1

Lens group
#2
(zoom)

Lens Group
#3
(focus)

FIG. 3D7

3A

6A

folding mirror

299

7A

3"

3

3B

9

6B

299   7B

12

50B

FIG. 3E1

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FIG. 3E2

Variable or dynamic
focus control
3B2

Variable focal length
(zoom) control 3B1

3A1
3A

3D

3C1

3C2

3E2

3E1

3''

2Z

FIG. 3E3

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29B

28

30B

6B

29A

22

3"

21

9

30A

500

6A

8

501

26

25'

FIG.3E4

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FIG. 3E5

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20"

12.118

3.500

3.500

6.4"

7.4"

7.4"

8.2"

8.4"

9.4"

27

6A

299

2.000

299

6B

8

Δ beam limit

7A

7B

camera FOV limit

9

3"

10

FIG. 3E6

FIG. 3E7

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* Variable FOV

FIG. 3E8

6A   3"   37A

6B

7A

299

38

7B   299   37B   10   50C

12   Stationary Planar
Laser Beam

FIG. 3F1

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FIG. 3F2

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FIG. 3F3

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FIG. 3G1

FIG. 392

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variable or dynamic focus control 3B2

Variable focal length (Zoom) control (3B1)

3A1

3A

3C1

3E2 3C2

3E1

22

3"

FIG. 363

variable focal length imaging lens
• variable focal distance

variable focal length imaging lens
dynamic focal distance

FIG. 3H

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Composite
Plane of
Laser
illumination

12

FOV Limits (VP)

SOD

21

20

22

19

18

9

29?

37A

6A

37B

6B

29?

3A

3B

FIG. 3I

FIG. 3J1

Mechanical oscillator

3-D Scanning Region

FIG 3J2

FIG. 3J3

Variable or dynamic focus control (3B2)

variable focal length (zoom) control (3B1)

3A1

3A

3D

3C2

3C1

3E1

3E1

22

3''

FIG. 3J4

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Composite
Plane of
Laser, Illumination
12

FOV
Limits (VO)

12

37A'
299
6A

18'
19
22
18
50'
21

3B"

3A

299
6B

37B'
18'

FIG. 3T5

Applications:
• hand-held Scanner
• Presentation Scanner

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50'

2-D
Hold-under
scanner

FIG. 3J6

Stationary
FoV (10)

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moving
Planar
Illuminator
Beam

12

4

FoV
Limits 10

7A

7B

6A

2

55

6B

5

8

FIG 4A

60

A

6A

55

299

57A

7A

6B

57B

55B

299

7B

60A

FIG. 4B1

FIG. 4B.2

(1) Fixed focal length imaging lens

(2) Fixed focal distance

6A

299

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optical axis

57A

55A / 55

55B

10' POV Limits

11A

57B

6B

299

microoscillation of Planar Laser Illumination Beam Components

60A

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FIG. 4B3

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299

6A

10'

9

57A

55

5.5B

mechanical
oscillator (58A)

7A

FOV(10') Limits

6B

299
7B

mechanical
oscillator
(58B)

← BOB

FIG 4C

FIG. 4C2

BO

2-D
Holde-Under
scanner

FIG. 4D

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FIG. 4E

Plane of laser illuminator

FOV Limits 10

Applications:
- Hand-held Scanner
- Presentation Scanner

FIG. 5A.

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6A   55'   173/385
58A   7A
299   67A
55B'
6B   57B
FOV (10')
Limits
299
58B
7B

moving Planer laser Illumination Beam
(12')

R
70A

FIG 5B1

57A

6A

X

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optical axis

277

(PoV)
10

55'

55B

55A

y

(1) Fixed focal length zoom lens
(2) Variable focal distance

57B

6B

277

70A

FIG. 5B2

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FIG.5B3

- Fixed focal length imaging lens
- Variable focal distance control

55B2'
55B1'
55A
55D
55C
55E
55'
22

FIG. 5B4

3-D Scanning
Region

FIG. 5C1

FIG. 5C

(1) variable focal length / airium lens

(2) Fixed focal distance

FIG.5C3

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- fixed focal length imaging lens
- variable focal distance control

55B2
55B1
55A
55D
55C
55E
55'
22

FIG. 5C4

70

FIG. 5D

(12') Moving Planar Laser Illumination Beam

Stationary FOV (10')

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FIG. 6A

FIG. 6.B1

(1) Variable focal length zoom lens
(2) variable focal distance

FIG. 6B2

6A

57A

299

55"

55A

11A

55B'

6B

299

57B

80A

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FIG. 6B3

FIG. 6B4

variable focal distance Control 55B3

variable focal length (Zoom) Control 55B2

55B1

55A

55B2a

55D

55E1

55C1

55E2

55C2

55C

22

55″

55" 55B" 6A 299 58A 57A 7B FOV (10') Limits 80B 299 6B 58B 57B 7B 12'

FIG. 6C1

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(1) Variable focal length anum lens
(2) Variable focal distance

FIG. 6c2

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FIG.6C3

variable focal distance control

5L B2

Variable focal length
(Zoom) Control (SSB3)

SSB/

SSA

SS"

SSD

SSE1

SSC1

SSC2

SSE2

SSE2

22

FIG. 6C4

80

FIG. 6C5

FIG. 6D1

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FIG. 6D2

FIG. 6D3

25"

26   housing   6A

(57A)
Planar Laser
Illumination
Beam folding/
Sweeping mirror

FOV
Folding
mirror
(9)

4.130   10.607

3.500

CCD FOV
(10")

21   8   55"   299   58A

22

Limits of
Stationary
3-D FOV
(10')

12'

Limits of
SWEPT
Planar Laser
Illumination
Beam

FIG. 6D4

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variable FOV

FIG. 6D5

55''

6B 9 299 57B

55B''

7B

91A 20

6A 299

57A

7A

30 FOV is
movable in 2-dimensions

FIG. 6E1

FIG. 6E2

(1) Variable Seal Length axum zone
(2) Variable focal distance

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FIG. 663

3-D scanning Region

10' (projected)

FIG. 6E4

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100

22
18
3A
6A
19
103
20
7A
FOV 10"
18
101
21
6B
102
holographic
imaging
disc
7B

Holographic PLIIM
System employing
Linear-type CCD Image
Detector

Converge
Surface

FIG. 7A

6B
101
12
3A
10"
100

102

FIG. 7B

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6B   55A
18   6A
22   37A'

19

20

18
21   37B'

102
101

3-D FOV

Holographic PLIIM
System employing
Area-Type
CCD Image
Detector
100'

FIG. 8A

12' Swept
Planar Laser
Illumination
Beam

101

6B
55A
37B'

3-D FOV
100'

102

FIG. 8B

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1-D CCD SCANNER EMBODIMENT

FIG. 9

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FIG. 10

129 Data Element Management Computer

123 PACKAGE VELOCITY MEASUREMENT SUBSYSTEM

124 PACKAGE HEIGHT/WIDTH/LENGTH PROFILING SUBSYSTEM

125 PACKAGE IN-TUNNEL INDICATION SUBSYSTEM

126 PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM

USER

130 GUI INTERFACE

131 DATA ELEMENT QUEUING, HANDLING, AND PROCESSING SUBSYSTEM

TCP / IP

TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)

1D (Linear) CCD CAMERA SUBSYSTEM

25'

LDIP

"PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM" (122)

127 I/O SUBSYSTEM

132 Network Controller (Ethernet, IP....)

133 Fiber Optic Network Controller

140

(RFID) (Data)

X-Ray Image Data, PFNA Data, Ethernet Ports

Data Element Queuing, Handling, and Processing Subsystem (131)

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Object Identification
Data Element
Symbolically Linked to
Object Attribute
Data Element No. 1...
Object Attribute Data
Element No. N

Data Element
Queuing, Handling, and
Processing and Linking
Mechanism

I/O
Unit

127

Object
Identification
Data Elements
Inputs,
(e.g. Bar Code
Reader, RFID
Reader)

Object
Attribute
Data
Inputs,
(e.g Object
Dimensions,
Weight,
X-ray analysis,
Neutron
Beam,
Analysis,
etc.)

FIG. 10A

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Primary Network
and/ or System
Functions:

A.
Specification of Object
Detection and
Tracking Capability of
System

Specification of Object Detection,Tracking, and Identification and
Attribute-Acquisition Capabilities of a Configured System or Network.

Detection and
Tracking of
Singulated
Objects

Detection and
Tracking of
Non-
Singulated
Objects

Identification
of Object Using
"Flying"
Spot Laser
Scanning
Beam
Techniques

Identification
of Object
Using RFID
Techniques

Identification
of Object Using
Image Capture
and Processing
Techniques

Identification
of Object Using
"Flying"
Spot Laser
Scanning
Beam
Techniques

Identification
of Object
Using RFID
Techniques

Identification
of Object Using
Image Capture
and Processing
Techniques

B.
Specification of Object
Identification
Capability of System

C.
Specification of
Object Attribute
Acquisition Capability
of System

Acquisition
of
Object
Dimensions
Only

Acquisition
of
Object
Dimensions
and Other
Object
Attributes

Acquisition
of
Object
Dimensions
Only

Acquisition
of
Object
Dimensions
and Other
Object
Attributes

Acquisition
of
Object
Dimensions
Only

Acquisition
of
Object
Dimensions
and Other
Object
Attributes

Acquisition
of
Object
Dimensions
Only

Acquisition
of
Object
Dimensions
and Other
Object
Attributes

1
2
3
4
5
6
7
8
9
10
11
12

FIG. 10B

```
┌─────────────────────────────────────────────────────────────────┐
│ Specify object detection and tracking capabilities of PLIIM- based│
│ network , system, and/or subsystem.                               │
└─────────────────────────────────────────────────────────────────┘
```
A

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ Specify object identification capabilities of PLIIM-based network,│
│ system, and/or subsystems.                                        │
└─────────────────────────────────────────────────────────────────┘
```
B

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ Specify object attribute acquisition capabilities of PLIIM-based  │
│ network, system, and/ or subsystem.                               │
└─────────────────────────────────────────────────────────────────┘
```
C

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ Determine the configuration of hardware components required to    │
│ build the configured system or network.                           │
└─────────────────────────────────────────────────────────────────┘
```
D

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ Determine the configuration of software components required to    │
│ build the configured system or network.                           │
└─────────────────────────────────────────────────────────────────┘
```
E

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ The system configuration manager program accesses the determined  │
│ software components from its Software Library (e.g. maintained on  │
│ an information server within the system engineering department),   │
│ and compiles these software components with all other required     │
│ software programs, to produce a complete System Software Package   │
│ designed for execution upon a particular operating system          │
│ supported upon the specified hardware configuration.               │
└─────────────────────────────────────────────────────────────────┘
```
F

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ The systems configuration manager program automatically generates │
│ an easy-to-follow set of Installation Instructions for the         │
│ configured system or network, guiding the technician through an    │
│ easy to follow installation and set-up procedures making sure all  │
│ of the necessary system and subsystem hardware components are      │
│ properly installed, and system and network parameters set up for   │
│ proper system operation and remote servicing.                      │
└─────────────────────────────────────────────────────────────────┘
```
G

↓

```
┌─────────────────────────────────────────────────────────────────┐
│ Once the hardware components of the system have been properly      │
│ installed and configured, the set up procedure properly completed, │
│ the technician is ready to operate and test the system for         │
│ troubles it may experience, and diagnose the same with or without  │
│ remote service assistance made available through the remote        │
│ monitoring, configuring, and servicing system of the present       │
│ invention, illustrated in Figs. 30A through 30D2                    │
└─────────────────────────────────────────────────────────────────┘
```
H

FIG. 10C

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FIG.11

Barcode

Image lift

Image Processing Computer for Barcode Symbol Recording and OCR Processing

21

Cropped Image strips

Video Image and

3h

PLIA

1A

Local Cartesian Coordinate System

11,20

CAMERA (variable zoom lens)

Focus (t+dt)

Zoom (t+dt)

Photo Integration Time

PLIA

6B

22

Camera Control Computer

LAN

Velocity (t)

Intensity (t)

Height (t)

Width (t)

Length (t)

Magnitude of (Polar-referenced) Range-map data specifies surface reflectivity

25'

120

LDIP Subsystem

12

Local Polar Coordinate System

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FIG. 12A

FIG.12B

power supply   motor controller   LDIP PC (512)   VLD rack   6A

main optics bench (510)

power Supply

Connectors

motor

3"   lens

Camera

Connector bracket

Camera folding mirror

9

power Supply

power Supply

motor

motor controller

6B

power supply   Connectors

Camera control computer (22) and image processing computer (21)

VLD rack

FIG. 12C

main optics bench
(510)

VLD(521B)

LDIP optics bench
(529)

163
LDIP
folding
mirror

collector
526

APD 525

524
lens

522
polygon

lens
527

collector
523

APD
528

VLD 521A

head drives
and LDIP
controller
card
529

6A

9

6B

FIG. 12D

Camera control Computer 22

533

Zoom lens group Translator

Focus lens Translator

534

1-D CCD image Detector (34)

+x

R Camera

+y

+d

Stationary lens group (530)

Zoom lens group (531)

Focus lens group (532)

+∂

FIG. 12E

(main optics)
(lens groups)

214/385

120

PLIB

AM Laser
Beams

FOV

Metrologic
150 Main Street
Blackwood, NJ 08808
NJ 08858-152

FIG. 13A

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FIG. 13A

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FIG. 13B

FIG. 13C

PLLIM-BASED PACKAGE IDENTIFICATION AND DIMENSIONING (PID) SYSTEM

FIG. 14

LDIP REAL-TIME PACKAGE HEIGHT PROFILE AND EDGE DETECTION METHOD

A — Raw data is received every 5ms; plus time stamp

B — Convert raw data into range profile R=f(Int. phase), referenced with respect to Polar Coordinate System symbolically embedded in LDIP Subsystem.

C — Use Geometric transformations
b[i] = R[i]sin(ang - 90) and
x[i] = R[i]tan(ang - 90) to convert range profile R[i] into height h[i] and position x[i] data.

D — Obtain current package height by finding prevailing height using edge detection without filtering (Fig. 16).

E — Find the coordinates of the left and right edges of package (LPE, RPE) by searching for the closest coordinates from the edges of the belt (X_a, X_b) toward the center thereof.

F — Analyze intensity data values {R(nt)} and determine the X coordinate position range $X_{\Delta 1}$, $X_{\Delta 2}$ (in R global) where the height intensity changes (i) within the spatial bounds (X_{LPE}, X_{RPE}) and (ii) beyond predetermined height intensity data thresholds.

G — Create time-stamped data set {X_{LPE}, h, X_{RPE}, V_B, nT} by assembling package left-edge coordinate (LPE), current package height (h), package right edge coordinate (RPE), X coordinate subrange where height values exhibit maximum intensity changes, package velocity (V_b), and time stamp (nT).

H — Send hextuple data set to camera control computer.

LDIP Package Dimensioner with Integrated Velocity Detection

551

Real-Time Package Height Profiling and Edge Detection Processing Module

550

belt velocity $\left(V_B\right)$

Fig. 15

LDIP Real Time Package Edge Detection

A — LPE = X[Ia]
i = Ia

B — RPE = X[Ib]
i = Ib

C — i < Ib - win?

D — H[i] .. H[i + win - 1] > Hthres?

E — X[i] ..X[i + win - 1] < Xa?

F — i++

G — LPE = X[i]

H — i > Ia + win?

I — H[i - win + 1] .. H[i] > Hthres?

J — X[i] ..X[i - win + 1] > Xb?

K — i--

L — RPE = X[i]

M — Exit

FIG. 16

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LDIP Subsystem (122)

Polar Coordinate System

polar (R, Θ)

$(I_a, \varnothing_a)$

$R (I_b, \varnothing_a)$
α_{192}

y

h_{max}

x

z

x_a

belt

X_{LPB}

conveyor belt

Global Cartesian
Coordinate
System

X_{RPB}

x_b

Fig. 17

INFORMATION MEASURED AT SCAN ANGLES BEFORE
COORDINATE TRANSFORMS

$\alpha_1 = \alpha_a$
$\alpha_{192} = \alpha_b$

$I_{192}, \emptyset_{192}$

$I_1, \emptyset,\ I_2, \emptyset_2$

α_{192}

$\alpha_1, \alpha_2,$
$(x,y)_{\alpha 1}$

Fig. 17A

RANGE AND POLAR ANGLE MEASURES TAKEN AT SCAN
ANGLE α BEFORE COORDINATE TRANSFORMS

Range and Polar

$R_1, \emptyset_1$ $R_2, \emptyset_2$ $R_i, \emptyset_i$ $R_{192}, \emptyset_{192}$

Fig. 17B

MEASURED PACKAGE HEIGHT AND POSITION VALUES
AFTER COORDINATE TRANSFORMS

H [ ]
Input height after
coordinate transforms

$(x,y)_{a2}$ $(x,y)_{\alpha=1}$ $(x,y)_{192}$

$y(\alpha_2)$
$x(\alpha_2)$

height value $y(\alpha_1)$ and
position value $x(\alpha_1)$
measured at left belt edge

Fig. 17C

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CAMERA CONTROL PROCESS CARRIED OUT WITHIN THE CAMERA CONTROL SUBSYSTEM OF EACH OBJECT IDENTIFICATION AND ATTRIBUTE ACQUISITION SYSTEM OF PRESENT INVENTION

Start

A — Camera Control Computer receives a time-stamped quintuple Data Set (i.e. coordinate of Left Package Edge, coordinate of Right Package Edge, height, velocity, and time stamp) from the LDIP Subsystem and stores the Data Set in a Package Data Buffer Structure having N=5 columns and M rows; Camera Control Computer optical power (milliwatts) which each PLIA must produce (using method in Figs. 18C), and transmits the computer optical power to each PLIA and dependent system.

B — Camera Control Computer analyzes height data in the Package Data Buffer and detects the occurrence of detecting discontinuities, and based on such detected height discontinuities, determines the corresponding coordinate position of the leading package edges by left-most and right-most coordinate values associated with the data set at this detected height discontinuity.

⑤

C — Camera Control Computer determines the height of the package associated with the leading package edges determined at Block B above.

N — Camera Control Computer transforms the position of left and right package edge (LPE, RPE) coordinates buffered in the deepest row of the Data Package Buffer at which the height value was determined at Block D to a Global Coordinate Reference System symbolically embedded in the conveyor belt structure beneath the LDIP Subsystem, as shown in Fig. 17.

D — Camera Control Computer analyzes the height values (i.e. coordinates) computed over previous raw data set processing cycles, and stored in the Package Data Buffer, and determines the "median" height of package, as well as the average "slope" of the package's laser scanned surface.

K — Camera Control Computer analyzes height value in the Package Data Buffer, and determines the speed of the package $(V_b(t))$.

③   ⑥   ⑦

①   ②   ④

FIG. 18A

④ ①

O — Camera Control Computer detects the x-coordinates of the package boundaries based on the spatially-transformed coordinate values of the left and right package edges (LPE, RPE) buffered in the Package Data Buffer.

P — Based on x-coordinates of the detected package boundaries (and optionally, the subrange of x-coordinates over which maximum range "intensity" data variations have been detected by the lens data of Fig. 15) determined at block O, the Camera Control Computer determines the corresponding pixel indices (i, j) in the Image Buffer which specify the image frame (i.e. region of interest) to be cropped from the image(s) to be subsequently captured by the IFD Subsystem.

E — Camera Control Computer uses Focus/Zoom Lookup Table in Fig. 21 to determine the focus and zoom lens group positions based on the height of the package determined at block D.

F — Camera Control Computer transmits Lens Group Moves Commands to the IFD Subsystem.

G — IFD Subsystem uses the Lens Group Movement Commands to move the lens groups to their desired positions.

H — Camera Control Computer checks resulting positions of moved lens groups.

I — Camera Control Computer corrects lens group positions.

J — Lens groups are moved to desired positions?
No / Yes

⑤

② ⑦ **L** ⑥ ⑦

Camera Control Computer uses the computed values of median package height, belt speed and the Photo-Integration Time Lookup Table in Fig. 23 to determine the photo-integration time parameter which will ensure that "square" image pixels are produced in captured package images (i.e. pixels having a 1:1 ratio); Camera Control Computer also uses (i) computed belt speed/velocity, (ii) the pre-specified image resolution (dpi), and (iii) computed "slope" of laser scanned surface so as to compute the surface-slope compensated Line Rate of the IFD subsystem that helps ensure that captured linear images have substantially constant pixel resolution (dpi) independent of the angular arrangement of the package surface during surface profiling and imaging operations.

M — Camera Control Computer generates digital control signals for the compute parameters--Photo-Integration Time Period and Compensated Line Rate-- and thereafter transmits these digital control signals to the CCD image detection array in the IFD Subsystem.

⑤

Q — Camera Control Computer uses package time-stamp (nT) and package velocity (V) to determine the "Start Time" of Image Frame Capture (STIC)

R — Camera Control Computer uses (i) the Start Time of Image Capture (STIC) determined at Block Q, to generate a command for starting Image Frame Capture, and also uses (ii) the pixel indices (I,j) determined at Block P to generate commands for cropping the corresponding slice of the "region of interest" in the image being captured and buffered in the Image Buffer within the IFD Subsystem.

S — Camera Control Computer transmits the command generated at Block R to the IFD Subsystem.

⑤

FIG. 18B

METHOD OF COMPUTING OPTICAL OUTPUT POWER FROM CASE DIODES IN PLANAR LASER ILUMINATION ARRAY (PLIA) FOR CONTROLLING CONSTANT WHITE LEVEL IN IMAGE PIXELS CAPTURED BY PLIIM-BASED LINEAR IMAGER

A ⟶
Compute the Line Rate of Linear Image Detection Array (dots/sec) based on computed Belt Velocity (inches/sec) and constant Image Resolution (dots/inch) desired, using equation:

Line Rate = (Belt Velocity) x (Image Resolution)

B ⟶
Compute the Photointegration Time ΔT of the Linear Image Detection Array based on the computed Line Rate using the formula:

Photointegration Time Period = 1/Line Rate

(A)

FIG. 18C1

$$\text{A}$$

Compute the Optical Power (milliwatts) of each PLIA based on computed
Photointegration Time Period (ΔT) using the following formula:

Optical Power of VLD (milliwatts) = $\dfrac{\text{constant}}{\text{Photointegration Time Period } \Delta T}$

FIG. 18C2

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METHOD OF COMPUTING COMPENSATED LINE RATE FOR CORRECTING VIEWING-ANGLE DISTORTION OCCURING IN IMAGES OF OBJECT SURFACES CAPTURED AS OBJECT SURFACES MOVE PAST PLIIM-BASED LINEAR IMAGER AT NON-ZERO SKEWED ANGLE

A ——
Compute the Line Rate of Linear Image, Image Detection Array (dots/sec) based on computed Belt Velocity (inches/sec) and constant Image Resolution (dots/inch) desired, using equation:

Line Rate = (Belt Velocity) x (Image Resolution)

B ——
Compute the Line Rate Compensation factor cosine (θ or $\emptyset$), where θ and $\emptyset$ is defined in Figs. 18E1 and 18E2 respectively as the computed average scope of the packages surface laser scanned by the AM laser beams powered by the LDIP subsystem, and is computed at Block D in Fig. 18A.

C ——
Compute the Compensated Line Rate for the IFD (i.e. camera) subsystem using the equation:

Compensated Line Rate = (Line Rate) x Cos(θ))

FIG. 18D

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CASE 1:
Top Down Imaging

120

AM Laser Beams

θ

Coplanar PLIB/FOV

Package

FIG. 18E1

CASE 2:
Side Imaging

Coplanar
PLIB/FOV

AM Laser Beams

Package

Ø

120

FIG. 18E2

X coordinate subrange where
maximum range "intensity"
variations have been detected

Left Package Edge (LDE)	Package Height (h)	Right Package Edge (RPE)	Package Velocity	Time-stamp (nT)	
					Row 1
					Row 2
					Row 3
					Row 4
					Row 5
					Row M

Package Data Buffer (FIFO)

Fig. 19

Columns

Rows

Camera Pixel Data Buffer
pixel indices (i,j,)

Fig. 20

Zoom and Focus Lens Group Position
Look-up Table

Distance from Camera H (mm)	Zoom group distance (mm) Y (Zoom)	Focus group distance (mm) Y (Focus)
1000	21.57489228	2.47E-05
1100	19.38089696	10.99009783
1200	17.10673434	20.65783177
1300	14.77137314	29.10917002
1400	12.39153565	36.47312595
1500	9.979114358	42.87845436
1600	7.540639114	48.44003358
1700	5.078794775	53.25495831
1800	2.595989366	57.40834303
1900	0.099972739	60.98883615

(use interpolation techniques for working distances between listed points in table)

FIG. 21.

Focus and Zoom lens movement vs. working distances

* note: a focal distance & zoom (ett. focal lengths) +
common lens are coupled (interdependent) in
Camera has a
** fixed aperture FSS
this common embodiment.

$y = 1.34870140E-17x^6 - 1.20583022E-13x^5 + 4.41176738E-10x^4 - 8.28465984E-07x^3 + 7.66947276E-04x^2 - 1.80415530E-01x - 9.41384873E+01$
$R^2 = 8.99999987E-01$

FOCUS

ZOOM

$y = 2.84791680E-18x^5 - 2.35121514E-14x^5 + 7.84795370E-11x^4 - 1.33426085E-07x^3 + 1.16929778E-04x^2 - 6.85049959E-02x - 4.87609108E+01$
$R^2 = 9.99999989E-01$

working distances(mm)

lens movement(mm)

→ zoom 1 → zoom 2 — Poly. (zoom 2) → Poly. (zoom 1)

← package height above conveyor

FIG. 22A

Conveyor-belt
surface

↑ above conveyor belt
(inches)

↑ Conveyor

Photo-Integration Time Look-Up Table

Distance From Camera (Package Height Above Conveyor)

1900 (mm)

1000 (mm)

1.0

600 Feet Per Minute (FPM)

Photo-Integration Time Value
That Ensures Square Image
Pixels (1:1 aspect ratio)

FIG. 22B

3D Surface Profile And High Resolution
Linear Image Data Capture
At PLIIM-Based Profiling
And Imaging System

Stationary Co-planar
PLIB/FOV

Camera parameters set during
photo-integration time period

PLIIM-Based Imager (25')

R (x', y', z')
PLIIM/ Cartesian

LDIP
(122)

R (x, y, z)
PLIIM/Cartesian

Linear
CCD Array

T_2

T_1

120

R LDIP/ Polar

Laser Beam 1
Laser Beam 2

Arbitrary 3-D
Object
Surface

Graphical Intelligence
(e.g. Characters,
Barcode)

FIG. 23A

Geometrical Modelling Of Arbitrary 3-D Object Surface
At Image Processing Computer

$R(x,y,z')_{PLIIM/Cartesian}$

LDIP
122

$R(x,y,z)_{LDIP/Cartesian}$

PLIIM-Based Imager 25'

IFD (camera) Module: {Camera Parameters}

3-D Vector-Based Model Of A "Pixel Ray", $R(x,y,z')_{Pixel}$
Specified in $R(x,y,z')_{PLIIM/Cartesian}$

Point Of Intersection PI (x',y',z') Between
Polygon-Surface Patch And Pixel-Ray R_{Pixel}
In System $R(x,y,z')_{PLIIM/Cartesian}$

Polygon-Surface Patch
$SI(x',y',z'), R_{PLIIM/Cartesian}$

$P(x',y',z')$

Photo-Detector

Coordinate
Transformation

$P(x',y',z')$

Polygon-Surface Patch
$SI(x,y,z), R_{LDIP/Cartesian}$

Linear CCD Array
Capturing High
Resolution Linear 2-D
Image each Photo-
integration Time Period

Area-Type 3-D
Surface Map Of
Arbitrary 3-D
Object Surface

FIG. 23B

METHOD OF AND APPARATUS FOR PERFORMING AUTOMATIC RECOGNITION OF GRAPHICAL INTELLIGENCE CONTAINED IN 2-D IMAGES CAPTURED FROM ARBITARY 3-D OBJECT SURFACES

STEP 1: At the unitary PLIIM-based object imaging and profiling system, use the laser doppler imaging and profiling (LDIP) subsystem employed therein to (i) consecutively capture a series of linear 3-D surface profile maps on a targeted arbitrary (e.g. non-planar or planar) 3-D object surface bearing forms of graphical intelligence and (ii) measure the velocity of the arbitrary 3-D object surface, wherein the polar coordinates of each point in the captured linear 3-D surface profile map are specified in a local polar coordinate system $R_{LDIP/polar}$, symbolically embedded within the LDIP subsystem.

— A

STEP 2: At the unitary PLIIM-based object imaging and profiling system, use coordinate transforms to automatically convert the polar coordinates of each point $p(\alpha, R)$ in the captured linear 3-D surface profile map into x,y, z Cartesian coordinates specified as p(x,y,z) in a local Cartesian coordinate system $R_{LDIP/Cartesian}$, symbolically embedded within the LDIP subsystem.

— B

STEP 3: At the unitary PLIIM-based object imaging and profiling system, use the PLIIM-based imager employed therein to consecutively capture high-resolution linear 2-D images of the arbitrary 3-D object surface bearing forms of graphical intelligence (e.g. symbol character strings), wherein (i) the x', y' coordinates of each pixel in each said captured high-resolution linear 2-D image is specified in local Cartesian coordinate system $R_{PLIIM/Cartesian}$ symbolically embedded within the PLIIM-based imager, and (ii) the intensity value of the pixel I(x',y') is associated with the x', y' Cartesian coordinates of the image detection element in the linear image detection array at which the pixel is detected, and (iii) wherein also the planar laser illumination beam (PLIB) of the PLIIM-based imager is spaced from the amplitude modulated (AM) laser scanning beam of the LDIP subsystem is about D centimeters.

— C

(A)

FIG. 23C1

(A)

STEP 4: At the unitary PLIIM-based object imaging and profiling system, capture and buffer the camera (IFD) parameters used to form and detect each linear high-resolution 2-D image captured during the corresponding photo-integration time period ΔT_K, by the PLIIM-based imager. —D

STEP 5: At the end of each photo-integration time period ΔT_K, use the unitary PLIIM-based object imaging and profiling system to transmit the following information elements to the Image Processing Computer for data storage and subsequent information processing:

(1) the converted coordinates x, y, z, of each point in the linear 3-D surface profile map of the arbitrary 3-D object surface captured during photo-integration time period ΔT_K;

(2) the measured velocity(ies) of the arbitrary 3-D object surface during photo-integration time period ΔT_K; —E

(3) the x', y' coordinates and intensity value I(x',y') of each pixel in each high- resolution linear 2-D image captured during photo-integration time period DTk and specified in the local Cartesian coordinate system $R_{PLIIM/Cartesian}$; and

(4) the captured camera (IFD) parameters used to form and detect each linear high-resolution 2-D image captured during the photo-integration time period ΔT_K

STEP 6: At the Image Processing Computer, receive the data elements transmitted from the PLIIM-based profiling and imaging system durin Step 5, buffer data elements (1) and (2) in a first FIFO buffer memory structure, and data elements (3) and (4) in a second FIFO buffer memory structure. —F

(B)

FIG. 23C2

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(B)

STEP 7: At the Image Processing Computer, use the x,y, z coordinates associated with a consecutively captured series of linear 3-D surface profile maps (i.e. stored in first FIFO memory storage structure)in order to construct a 3-D polygon-mesh surface representation of said arbitrary 3-D object surface, represented by $S_{LDIP}(x,y,z)$ and having (i) vertices specified by x,y, z in local coordinate reference system $R_{PLIIM/Cartesian}$, and (ii) planar polygon surface patches $s_i(x,y,z)$ and being defined by a set of said vertices. — G

STEP 8: At the Image Processing Computer, convert the x',y',z' coordinates of each vertex in the 3-D polygon-mesh surface representation into the local Cartesian coordinate reference system $R_{PLIIM/Cartesian}$ symbolically embedded within the PLIIM-based imager. — H

STEP 9: At the Image Processing Computer, specify the x',y', z' coordinates of each i-th planar polygon surface patch s(x,y,z) represented in the local Cartesian coordinate reference system $R_{PLIIM/Cartesian}$, so as to produce a set of corresponding polygon surface patch $\{s_i(x',y',z')\}$ represented in system $R_{PLIIM/Cartesian}$ — I

STEP 10: At the Image Processing Computer, for a selected linear high-resolution 2-D image captured at photo-integration time period ΔT_K, and spatially corresponding to one of the linear 3-D surface profile maps employed at Step 7, use the camera (IFD) parameters used and recorded (i.e. captured) during the corresponding photo-integration time period in order to construct a 3-D vector-based "pixel ray" model specifying the optical formation of each pixel in the linear 2-D image, wherein a pixel ray reflected off a point on the arbitrary 3-D object surface is focused through the camera's image formation optics (i.e. configured by the camera parameters) and is detected at the pixel's detection element in the linear image detection array of the IFD (camera) subsystem. — J

(C)

FIG. 23C3

Ⓒ 237/385

STEP 11: At the Image Processing Computer, for each laser beam ray (producing one of the pixels in said selected linear 2-D image), (i) determine which polygon surface patch $s_i(x, y, z)$ the pixel ray intersects, (ii) compute the x, y, z coordinates of the point of intersection (POI) between the pixel ray and the polygon surface patch represented in Cartesian coordinate reference system $R_{PLIIM/Cartesian}$, and (iii) designate the computed set of points of intersection as $\{p_i(x,y,z)\}$. ──K

STEP 12: At the Image Processing Computer, for each laser beam ray passing through a determined polygon surface patch $s(x',y', z')$ at a computed point of intersection $p_i(x, y, z)$, assign the intensity value $I(x',y')$ of the pixel ray to the x', y', z' coordinates of the point of intersection, thereby producing a linear high-resolution 3-D image comprising a 2-D array of pixels, each said pixel pixel having as its attributes (i) an Intensity value $I(x',y',z')$ and (ii) coordinates x', y', z' specified in the local Cartesian coordinate reference system $R_{PLIIM/Cartesian}$. ──L

STEP 13: Put the computed linear high-resolution 3-D image in a third FIFO memory storage structure in the image processing computer. ──M

STEP 14: Repeat Steps 1-6 to update the first and second FIFO data queues maintained in the image processing computer, and Steps 7-13 to update the consecutively computed linear high-resolution 3-D image stored in the third FIFO memory storage structure. ──N

STEP 15: Assemble in an image buffer in the image processing computer, a set of consecutively computed linear high-resolution 3-D images retrieved from the third FIFO data storage device so as to construct an "area-type" high-resolution 3-D image of said arbitrary 3-D object surface. ──O

Ⓓ

FIG. 23C4

(D)

STEP 16: At the Image Processing Computer, map the intensity value I(x', y', z') of each pixel in the computed area-type 3-D image onto the x',y',z' coordinates of the points on a uniformly-spaced apart "grid" positioned perpendicular to the optical axis of the camera subsystem (i.e. to model the 2-D planar substrate on which the forms of graphical intelligence was originally rendered), wherein said mapping process involves using an intensity weighing function based on the x', y', z' coordinate values of each pixel in the area-type high-resolution 3-D image, thereby producing an area-type high-resolution 2-D image of the 2-D planar substrate surface bearing said forms of graphical intelligence (e.g. symbol character strings).

— P

STEP 17: At the Image Processing Computer, use said OCR algorithm to perform automated recognition of graphical intelligence contained in said area-type high-resolution 2-D image of said 2-D planar substrate surface so as to recognize said graphical intelligence and generate symbolic knowledge structures representative thereof.

— Q

STEP 18: Repeat Steps 1-17 as often as required to recognize changes in graphical intelligence on the arbitrary moving 3-D object surface.

— R

FIG. 23C5

239/385'

Photo-Integration Time Look-up Table

600 feet per minute (FPM)

FIG. 22B

belt speed (package velocity)

Distance from camera (package height above conveyor)

1900(mm)

1000(mm)

10

Photo-integration time value that ensures square image pixels (1:1 aspect ratio)

1000 mm
10 FPM

LOW RESOLUTION 2D CCD CAMERA (61)

HIGH RESOLUTION 2D CCD CAMERA (55")

25"

LDIP (22)

041

PACKAGE

21

CONVEYOR BELT

FIG 24

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FIG. 25

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Data Element Queuing, Handling, and Processing Subsystem (131)

2613

Object Identification
Data Element
Symbolically Linked to
Object Attribute
Data Element No. 1...
Object Attribute Data
Element No. N

Data Element
Queuing, Handling, and
Processing and Linking
Mechanism

2610

I/O
Unit

127

2611

Object
Identification
Data Elements
Inputs
(e.g. Bar Code
Reader, RFID
Reader)

Object
Attribute
Data
Inputs,
(e.g Object
Dimensions,
Weight,
X-ray analysis,
Neutron
Beam,
Analysis,
etc.)

2612

FIG. 25A

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Specification of Object Detection, Tracking, and Identification and
Attribute-Acquisition Capabilities of a Configured System or Network.

Primary Network
and/ or System
Functions:

A.
Specification of Object
Detection and
Tracking Capability of
System

B.
Specification of Object
Identification
Capability of System

C.
Specification of
Object Attribute
Acquisition Capability
of System

Detection and
Tracking of
Singulated
Objects

Detection and
Tracking of
Non-
Singulated
Objects

Identification
of Object Using
"Flying"
Spot Laser
Scanning
Beam
Techniques

Identification
of Object
Using RFID
Techniques

Identification
of Object Using
Image Capture
and Processing
Techniques

Identification
of Object Using
"Flying"
Spot Laser
Scanning
Beam
Techniques

Identification
of Object
Using RFID
Techniques

Identification
of Object Using
Image Capture
and Processing
Techniques

1 — Acquisition of Object Dimensions Only

2 — Acquisition of Object Dimensions and Other Object Attributes

3 — Acquisition of Object Dimensions and Other Object Attributes

4 — Acquisition of Object Dimensions Only

5 — Acquisition of Object Dimensions Only

6 — Acquisition of Object Dimensions and Other Object Attributes

7 — Acquisition of Object Dimensions Only

8 — Acquisition of Object Dimensions and Other Object Attributes

9 — Acquisition of Object Dimensions and Other Object Attributes

10 — Acquisition of Object Dimensions Only

11 — Acquisition of Object Dimensions Only

12 — Acquisition of Object Dimensions and Other Object Attributes

FIG. 25B

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A	Specify object detection and tracking capabilities of PLIIM- based network , system, and/or subsystem.

B	Specify object identification capabilities of PLIIM-based network , system, and/or subsystems.

C	Specify object attribute acquisition capabilities of PLIIM-based network, system, and/ or subsystem.

D	Determine the configuration of hardware components required to build the configured system or network.

E	Determine the configuration of software components required to build the configured system or network.

F	The system configuration manager program accesses the determined software components from its Software Library (e.g. maintained on an information server within the system engineering department), and compiles these software components with all other required software programs, to produce a complete System Software Package designed for execution upon a particular operating system supported upon the specified hardware configuration.

G	The systems configuration manager program automatically generates an easy-to-follow set of Installation Instructions for the configured system or network, guiding the technician through an easy to follow Installation and set-up procedures making sure all of the necessary system and subsystem hardware components are properly installed, and system and network parameters set up for proper system operation and remote servicing.

H	Once the hardware components of the system have been properly installed and configured, the set up procedure properly completed, the technician is ready to operate and test the system for troubles it may experience, and diagnose the same with or without remote service assistance made available through the remote monitoring, configuring, and servicing system of the present invention, illustrated in Figs. 30A through 30D2

FIG. 25C

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FIG. 26

Barcode

Image lift

Image Processing Computer for Barcode Symbol Recording and OCR Processing 21

Video Image and Cropped Image strips

PLIA 6A

CAMERA (Specific FoV) 55'''

Local Cartesian Coordinate System

PLIA 6B

Focus (t+dt)/
Zoom (t+dt)/
Photo Integration Time

Camera Control Computer 22

LAN

Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)

Magnitude of (Polar-referenced) Range-map data specifies surface reflectivity

LDIP Subsystem 122

Local Polar Coordinate System

Low Resolution 2D CCD Camera Subsystem 61

25''

140

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Top PID unit
122
120
Camera Field of View
DimensionerField of View
120
Right PID units
570
120
Left PID unit
571A
573
571B
120
Bottom PID UNIT
571
Encoder
PID: Package Identification and Dimensioning unit
576

FIG. 27

(TCP/IP) Remote Diagnostics over WWW
Control Ethernet Hub
575
570

122
120
CCD Dimensioner
Camera
Top (Master) CCD Camera control computer
55"
22
Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms
Camera Data, 80 MBytes/sec

Camera
55"
22
120
Left CCD Camera Control computer
Camera Data, 80 MBytes/sec
572

Camera
55"
22
120
Right CCD Camera Control computer
Camera Data, 80 MBytes/sec

Camera
55"
22
120
Bottom CCD Camera control computer
Camera Data, 80 MBytes/sec

576
Encoder
(tachometer) EXTERNAL

FIG. 28

Parcel ID
Remote Diagnostics

Control
Ethernet
Hub   575

Dimensioner   122   120

Top (Master)
CCD Camera

Camera   55"   122

Parcel ID, Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms

Camera   55"   122   120

Left
CCD Camera

577

Camera   55"   122   120

Right
CCD Camera

Data
Ethernet
Switch

572

Camera   55"   122   120

Bottom
CCD Camera

Ethernet over
fiber optical
communication
medium

Encoder   576

570

Barcode Data,
4 x 1 kBytes
Binarized Image Data,
4 x 100 kBytes

Keying
Workstation

580

FIG. 29

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Parcel ID
Remote Diagnostics

Control
Ethernet
Hub ~ 575

Dimensioner

Camera

Top (Master)
CCD Camera

Parcel ID, Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms

Camera

Left
CCD Camera

577

Camera

Right
CCD Camera

572

Data
Ethernet
Switch

Camera

Bottom
CCD Camera

Ethernet over
fiber optical
communication
medium

Encoder ~ 576

Barcode Data,
4 x 1 kBytes
Binarized Image Data,
4 x 100 kBytes

570

Keying
workstation

589

FIG. 29

FIG 30

FIG. 30A

- Network, System, and Subsystem Configuration Parameters

2621 Tunnel-Based LAN

Tunnel-Based LAN — 2621

Tunnel-Based LAN — 2621

Internet Infrastructure

Management Server

Database Central MIB — 2626

LAN HTTP/ Servlet Server — 2625

LAN Hub — 2624

LAN Router — 2623

HTTP | SNMP Agent | SMTP | Local MIB
FTP | Ethernet
TCP/IP
OS
— 120 — 2625

HTTP | SNMP Agent | SMTP | Local MIB
FTP | Ethernet
TCP/IP
OS
— 120' — 2625

HTTP | SNMP Agent | SMTP | Local MIB
FTP | Ethernet
TCP/IP
OS
— 120' — 2625

- System Level Parameters
- Subsystem Level Parameters

Remote Service Client Computer — 2622

Network Management Station (NMS), i.e. management console

2620

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FIG. 30B

Network Configuration Parameters:

[Router IP address; no. of nodes (i.e. systems) in LAN; passwords, LAN location; name of customer facility; technical contact; phone no.; domain name; object identity codes; object attribute acquisition codes;.....]

System Configuration Parameters:

[System IP Address; passwords; object identity codes; object attribute acquisition codes;....]

Monitorable and/or Configurable Parameters for Subsystems Within Each System:

These subsystems generate object identity parameters

☐ PLIIM-based object identification subsystem: [object identity code; object attribute acquisition codes;....]
   ☐ PLIM Subsystem: [VLD status; power VLD; TIM function; temp;....]
   ☐ IFD (Camera) Subsystem: [sensor temp; .....]
   ☐ Image Processing Subsystem (Computer): [processor load history; system up time; # of frames (pgs); barcode read rate; current line rate;....]
   ☐ Camera Contact Subsystem (Computer): [number of frames dropped; number of focused zoom commands; number and kinds of motor control errors;....]

This system links object attribute data element parameters(i.e. object identity data element) to corresponding object identity parameters (i.e. object attribute data element)

☐ RFID-based object identification subsystem: [....]

☐ Object identity and attribute data element queuing, handling and processing subsystem: [....]

☐ LDIP object identification, velocity-measurement, and dimensioning subsystem: [....]
   ☐ Object velocity measurement subsystem: [polygon RPM; polygon laser output X; channel X drift; channel X noise; trigger error events; instant lock reference drift; temperature]
   ☐ Object H/W/L profiling subsystem
   ☐ Object detection subsystem: [non- singulation/ singulation code;....]

These subsystems generate object attribute parameters

☐ X-ray scanning subsystem: [....]

☐ Neutron-beam scanning subsystem: [....]

FIG. 30C

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Box	Content
A	Use an Internet-enabled client computer to establish a network connection (via network router) with an HTTP server in the tunnel-based LAN requiring remote monitoring, control and/or service.
B	Use an Internet-enabled client computer to access an RMCS management console (GUI) from the HTTP server and display the same.
C	Use the RMCS management console to display network configuration parameters in the tunnel-based LAN, and to use these network configuration parameters to monitor configuration parameters and performance parameters of each system in the network.
D	Use the RMCS management console to monitor the configuration and other monitorable parameters of each subsystem in the system.
E	Use the RMCS management console to run a diagnostic program to trouble shoot any performance problems with the system.
F	Using information collected by the diagnostic program and the RCMS management console, reconfigure selected parameters in the system and instruct any hardware repairs that may be required at the LAN location.

FIG. 30D1

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Use the RMCS management console to rerun diagnostic programs on troubled systems and subsystems in the LAN after parameter reconfiguration and/or hardware repair at the LAN location, so as to test the performance of such systems and subsystems and the overall tunnel based LAN.

G

Use the RMCS management console to monitor parameters of the system and subsystems in the tunnel based LAN, from time to time, to determine whether or not the system and/or network tunnel is required.

H

Use the RMCS management console to record all monitored parameter records and result of diagnostic programs in a customer service database for future reference, and access during subsequent remote service calls over the Internet.

I

FIG. 30D2

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CCD Camera-Based Tunnel System
Employing Package Coordinate Data
Driven Method of Automatic Camera
Zoom and Focus Control

570

Master unit
120 (122)

Package dimensioning
Subsystem
120

Package
velocity
Detection
Subsystem

R_{local0}

Dimensioned Field of View

R_{local1}
(Slave unit #1)

R_{global}

Camera Field of View

$+A$

$+c$

$+B$

x

Encoder

576

Package

R_{local2}
(Slave unit #2)

571A

573

Camera
Field of
View

R_{local3}
(Slave unit #3)

571B

Package Coordinate Data $\parallel R_{global}$

$+G \implies$ Package Coordinate Data $\parallel R_{local i}$

R_{global}

FIG.31

For each package transported through tunnel system, master unit (with package dimensioning subsystem and velocity detection subsystem) generates package height, width, length and velocity data $\{H,W,L,V\}_G$, referenced with respect to global coordinate reference system R_{global}, and transmits such package dimension data to each slave unit downstream, using the system's data communications network.

— A

Each slave unit receives the transmitted package height, width and length data $\{H,W,L,V\}_G$ and converts this coordinate information into the slave unit's local coordinate reference system $R_{local\,I}, \{H,W,L,V\}_I$

— B

The camera control computer in each slave unit uses the converted package height, width, length data $\{H,W,L\}_I$ and package velocity data to generate camera control signals for driving the camera subsystem in the slave unit to zoom and focus in on the transported package as it moves by the slave unit, while ensuring that captured images having substantially constant O.P.I. Resolution and 1:1 aspect ratio.

— C

(A)

FIG. 32A

(A) 256/385

Each slave unit captures images acquired by its intelligently controlled camera subsystem, buffers the same, and processes the images to decode bar code symbol identifiers represented in said images, and/or to perform optical character recognition (OCR) thereupon. —— D

The slave unit which decodes a bar code symbol in a processed image automatically transmits a package identification data element (containing symbol character data representative of the decoded bar code symbol) to the master unit (or other designated system control unit employing data element management functionalities) for package data element processing. —— E

Master unit time-stamps received package identification data element, places said data element in a data queue, and processes package identification data elements and time-stamped package dimension data elements in said queue to link each package identification data element with one said corresponding package dimension data element. —— F

FIG. 32B

FIG. 31A

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580   POV#1   Laser dimensioning

589

Object

POV#2

FIG. 33A

583 stationary
PLIB/FOV#1

Laser
Dimensioning Beams

Produce
(eg. lettuce)

585

stationary
PLIB/
POV#2

SIDE
UNIT
(586B)

584

← 580

581

582 Bottom
unit
(586A)

scale(587)

FIG. 33B

258/385'

586A

587

580

589

Host Computer
System
(2.95 Register)

587

Electronic
Produce
Weight Scale

588

586B

USER

125

Product
Detection
Subsystem

586B

IMAGING,
DETECTION AND
DIMENSIONING
SUBSYSTEM
(TL)

(1)
PACKAGE
HEIGHT/WIDTH/
LENGTH PROFILING
SUBSYSTEM

(1)
PACKAGE
VELOCITY
MEASUREMENT
SUBSYSTEM

System Control/Mangmnt.
Computer

590

1-D CCD
SUBSYSTEM

582

I/O
SUBSYSTEM
127

132

B32

25

PUA

PUA

CMOS
Camera Chip

Camera Control
Computer

I/O
Sub

Mkt
Chip

132,127

Network
Communication
Medium

586A

FIG.33C

FIG. 34A

FIG. 34B

FIG. 34C

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Planar Laser
Illumination
Beam 621
(PLIB)
622
Surface Emitting
Laser (SEL)

626

624

"PLIM on Semiconductor
chip"
620

625

623 Package

FIG. 35A

620

FIG. 35A

626

624

625 FIG 35B

FIG. 35A

FIG. 35B

FIG. 35C

FIG. 37

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371

composite PLIB from i-th
Linear SEL array (370)

362

3D FOV

360

365

361n

364

366

364A

367

FIG. 38A

360

372

364

362

363

369

368 361

364A

FIG. 38B

FIG.39A

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1215A

1219B

1221B

1222

1216

1202

1219A

1221A   1222   1214

1215B

1204

FIG. 39B

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1206

1207

1217

1216

1219A

1219B

1220

1218

1221A

1221B

1222

1222

1203

1205

FIG. 39C

1222　　1215A　　1216　　1222

1215B

FIG. 39D

1214

1215A　　1216　　1219A

FOV (1205)

PLIB (1203)

Coplanar

1214

FIG. 39E

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FIG. 40A1

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1245

1248

1250

124U

1251

Data Buffer

Image Controller

Fixed Focal length/Fixed Focal Distance

1247

1244

IFOM

1227

6

U.P. Driver

U.P. Driver

1252

Image Processing Computer

1253

Camera Control Computer

1226

despeckling mechanism

1227

1255

Display Panel Driver

1254

LCD Panel

1259

IR-Based Object Detection Subsystem

IR Sounding Beam

Data Transfer Activation Switch

Keypad Driver

1256

Touch Keypad

1258

1257

1261

Auto/IR OD.

Data Transfer mechanism

to Host computer

1260

FIG. 40A2

1265

1268

Fixed Focal length / Fixed Focal Distance

1267

1269

1279

IFOM

1270

1227

1266

Image Capture

1271

Data Buffer

VLD Driver

1279

VLD Driver

1272

Image Processing Computer

Camera Control Computer

1273

6

1226

1227

1278

1275

1274

Display Panel Driver

LCD Panel

1274

Data Transfer Activation Switch

Keypad Driver

Touch Keypad

1276

1277

Auto / User Object Detection

1281

Data Transfer Mechanism

Host

1280

FIG. 40A3

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1285

1288

Fixed Focal Length/Fixed Focal Distance

1289

1299

1287

FFON

1290

1286

Image Grabber

1227

1291

Data Buffer

1292

Image Processing Computer

Control Control Computer

1293

1298

1227

1226

Display Panel Driver

LCD Panel

1295

1294

Data Transfer Activation Switch

Keypad Driver

Touch Keypad

1296

1297

1301

Data Transfer Mechanism

Host

Auto/passive object detect
CCD

1300

FIG. 40A4

FIG. 40A5

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FIG. 40B1

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FIG. 40B2

Auto/IR-Based Object Detection

IR-Based Object Detection Subsystem — 1353

IR Sensing Beam — (1354)

LCD Panel — 1349

Touch Keypad — 1351

Display = Panel Driver — 1350

Keypad Driver — 1352

Host

Data Activation Switch — 1356

Data Transfer Switch — 1355

Camera Control Computer — 1348

Data Buffer — 1346

Image Processing Computer — 1347

Image Controller — 1345

Field and Height or Wide Image Beam — 1344

1343

1342

1227

1226 1227

6

1340

1341

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FIG. 4063

Find and Length
Variable or Dynamic Row

1227

1374

1364

1363

1362

1227

1226

6

VLD Decode

VLD Decode

1373

370

Camera
Control
Computer

368

1365

Image
Switch

Data
Buffer

1366

Image
Processing
Computer

1367

LCD
Panel

1369

Display =
 Anel Driver

Touch
Keypad

371

Keypad
Driver

372

Data
Activation
Switch

1376

DMA
Transfer
Switch

1375

Host

Automatic/Cross Object
Detect

1361

1360

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Automatic / CCD offset when
(interior)

FIG 40B4

1389

1391

1392

1395

1390

1387

1386

1381

1380

1383

1393

1388

1390

1227

1226

1382

1384

1374

1227

LCD Panel

Touch Keypad

Display = Panel Driver

Keypad Driver

Data Activation Switch

Data Transfer Mechanism

Data Pipe

Image Carrying Computer

Camera Control Computer

Image Carrier

LCD Driver

LCD Driver

Fixed and heights
velocity = dynamic mag

Fixed red length
Variable red
dynamic row
1404

1403

1402

1227

1226 1227

16

VLV
Driver

17

LCD
Driver

1405

Camera
Control
Computer

1413

1408

Image
Select

Data
Buffer

Image
Processing
Computer

Data
Activation
Switch

Data
Transfer
Switch

1414

1415

Host

1401

1406

1407

LCD
Panel

1409

Display =
Panel Driver

1410

Touch
Keypad

1411

Keypad
Driver

1412

* Automatic/BCD only!

no object
Detect

FIG. 40B5

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FIG.40C1

Manual Activation

(1424)

1427

1427

1426

6

1423

1422

1425

1429

LCD Panel

1430

Display And Driver

Gamma Control Computer

1428

Keypad Driver

1432

Touch Keypad

1431

Image Counter

Data Buffer

Image Processing Computer

Manual Trigger Activator Switch

1433

1420

1421

1426

1422

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FIG. 40C2

Automatic/IR-based object detection

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FIG. 40C3

1459
1458
1457
1460
1456
1461
1462
1455
1468
1465
1463
1226
1464
LCD Panel
Display Panel Driver
Touch Keypad
Keypad Driver
1466
1467
Data Activation Switch
Data Transfer mechanism
Host
1469
1470
1471

Automatic / User object Detection

282/385

FIG. 40C4

FIG. 40C5

Automatic / BCD only
— no object detect

1479

1509

1478

1477

1227

1227

1226

6

18 WDr Medu

1503 1505

1502

1500 Image Controller

Gamma Output Converter

1508

Display Panel Driver

LCD Panel

1504

Keypad Driver

Touch Keypad

1506

1507

1500

1496

Data Buffer

1501

Image Processing Computer

1502

Data Transfer activation switch

1511

Data Transfer Mechanism

1510

1495

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1520

1521

1522

1527

1526

1528

1529

1531

1530

1524

PLFB (1523)

POV (1525)

Data Comm. Link

Host Computer/Network

FIG. 41A

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1534A

METROLOGIC™

1541B

1536
Linear Image array with
vertically elongated Image detection
elements

1539

1544B

1545B

1537

1543

1532

1552

1532

1535

538

1541A

1544A

1545A

1534B

1524

F.I.G. 41B

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1536

1532

1539

1541A

1541B

1544B

1544B

1545B

1545B

1522

1540

1542

FIG. 41C

1522

1534A

1540

1542

1535

1541A

1544A

1545B

FIG. 41D

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PLIB (383)

4758B

4714B (RPA2)

4718

4723

4704

4706

4702

47 04

4707

4709

4708

4712

4742A (MMU)

4710

FOV
(4704)

4754A

4711

Data Comm.
Link

4742

Host Computer/network

4700

FIG 42

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1553 (FOV)

1553 (PLTB)

1552

1558

1557

1554

1556

1550

1559

1560

1551

1551

Data Comm.
Link

1562

1563
Host Computer/Network

FIG.42A

METROLOGIC™

1565A

1567

1577

1578

1566

1564

1576

1577

1578

1576

1552

1565B

1554

FIG. 42B

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1568   1567

1564   ← 1552

1568
1572A
1577
1576
1575   1578   1570   1577
1575
1578   1576
1575   1578

1555

1553

FIG. 42C

1552

1565A   1566   1577   1578

1553 1555

1572A   1576

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FIG. 43A

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1595A

1596

1603

1604

1594

1603

1602

1604

1602

1582

1595B

1584

F.I.G. 43B

FIG. 43C

FIG. 43D

FIG. 44A

FIG. 44B

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FIG.44C

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1637

1642

1643

1639

1638 (PLCB)

1640 (FOV)

1644

1635

1645

1636

1646

1647

Data Comm. Link

1648

Host Computer/Network

FIG. 45A

METROLOGIC™

1650A

1655B 1657

1651

1658 1656

1649

1655A

1656 1658

1657

1637

1650B

1639

FIG. 45B

FIG.45C

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FIG. 46A

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1675A

1678
1680B
1682
1683

1676

1674

1680A
1682
1683

1662

1675B

1664

FIG. 46B

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FIG. 46C

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1693 (PLIB)

1685 (FOV)

1698

1697

1694

1696

1692

1690

1699

1700

1691

1701

Data Comm. Link

1703 Host Computer/Network

1702

FIG. 47A

304/385

1705A

1692

1706

1712 ← 1711

1713

1704

1712

1711 →

1713

1705B

1694

F I G. 47B

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FIG. 47C

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1720

1721

1722

1726

1728

1727

1724

1729

1730

1731

1732

1723 (FLD)

1725 (FOV)

Data Comm. Link

1733

Host Computer/Network

FIG. 48A

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METROLOGIC™

1735B

1736

1738B

1739B

1734

1738A

1739B

1722

1735B

1724

FIG. 48B

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FIG.48C

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FIG. 49A

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FIG. 49B

(311/385)

1757 1746
1756
1758
1760A
1759
1760B
1761
1762
1763
1762
1761
1763

SIMF

1745

1743

FIG.49C

(1773)
(PCB)

(1775)
(FOV)

(1778)

(1777)

(1774)

(1772)

(1776)

(1770)

(1771)

(1780)

(1771)

(1781)

(1782)

(1783)

Data Comm.
Link

Host Computer/Network

FIG 50A

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METROLOGIC™   1785A

1793 1790B 1792

1786   1791

1784

1790A

1772

1785B

774

F.I.G. 50B

314/385

1787   1776

1772

1784

1789

1788 1790A

1790B

1792

1791

1793

1775

1773

FIG. 50C

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FIG. 51A

(1803)
(P.I.B)

(1805)
(FOV)

(1808)

(1807)

(1804)

(1802)

(1806)

(1800)

(1809)

(1810)

(1801)

(1811)

(1812)

Data Comm.
Link

(1813)
Host Computer/Network

1-D
diffraction
(show...)...

METROLOGIC™

1814 A

1821

1819B

1815

1813

1819A

1802

1914 B

1804

F.I.G. 51B

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FIG. 51C

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FIG.52

4815B
4814B
4816A
4818B
4804
PLIB (4803)
3D Fov (4805)

4815A
4813
4817
4802
4804
4807
4805
4809
4808
4801
4814A
4810
4818A
4816A
4811
Data Comm. Link
4812
Host Computer/network
4800

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PIB (1833)

3D FoV (1835)

1838

1837

1834

1832

1836

1839

1830

1840

1831

1841

1842

Data Comm. Link

1843

Host Computer/Network

FIG.52A

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METROLOGIC™

1845A

1848
1853
1851B
1836
1850B
1816
1852
1849B
1844
1854
1847
1850A
1851A
1849A
1852

1832

1845B

1834

FIG. 52B

Fig. 1I3A-3B

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FIG. 53A1

fixed-focal-length/
fixed-focal-distance

1869
6
1869
1868A
1868B
1862
1862
1865
1861
1864
11
11
18
18
1866
1873
1871
LCD Panel
1872
Touch Keypad
1874
Display Driver
Keypad Driver
1875
Camera Control Surface
Image Capture
Data Buffer
Image Processing Computer (w/memory)
Host
Manual Activation Trigger Switch
Manual
1862'
1867
1870
1876
1860

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Fixed-focal length/
fixed-focal-distance

1888A
1887

1862
1889
6

1888B

1885

1861

1896
(1897)

IR-Based
Object Detection
Subsystem

IR Sensing
Beam

Auto/IR-OD

1884

18
18

1892

1893

LCD
Panel

1894

Touch
Keypad

1886

Image
Control
Computer

Display
Panel
Driver

Keypad
Driver

1895

FIG. 53A2

1883

Data
Buffer

Image
Program
Computer
(w/memory)

1897

1887

Host

1899

Data
Activation
Switch

Data Transfer
Mechanism

1898

1890

1880

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Auto/close object detection

Fixed-focal-length/
fixed-focal-distance

2003

2007

2006A

1862

6

2007

2006B

1861

11

18

2002

11

18

2010

2011

LCD
Panel

Display
Buffer
Driver

2009

Camera
Control
Surface

Keypad
Driver

2012

Touch
Keypad

2013

2004

Frame
Grabber

2005

Data
Buffer

Image
Processing
Computer
(w/memory)

2008

Data Transfer
Activation
Switch

201

2016

HOST

Data
Transfer
Mechanism

2000

FIG. 53A3

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FIG. 53A4

Auto/Manual Object Detection using CCD array

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FIG. 53A5

2040

Fixed-focal length/
fixed focal distance

Auto/BCD only in object
detection

2043
(2055)
2042
2044
2045
2048
2057   Data Transfer
       Activation
       Switch
2056   Data Transfer
       Mechanism
→ Host
2049
2054
2051   LCD
       panel
       Display
       Driver
2050
2052   Touch
       Keypad
       Keypad
       Driver
2053
1862
1861
18
11

326/385

Fixed focal length/
Variable focal distance

Manual

FIG. 53B1

327/385

fixed focal length/
variable focal distance

FIG. 53B2

Auto/IR object detection

IR-Band object detection subsystem

IR-Sensing beam

LCD Panel

Touch Keypad

Display Panel Driver

Keypad Driver

Camera Control Computer

Image Memory

Data Buffer

Auto Transfer Activation Switch

Data Transfer mechanism

Host

328/385

fixed focal length/
variable focal distance

3003

3014

3007
3006A

1862

3006B
3007

181

3010

LCD
Panel

Auto/user object detection

3012

Touch
Keypad

3002

3011

Display
Panel
Driver

Keypad
Driver

3012

3013

Camera
Control
Computer

3009

3004

3001

3005
Data Buffer

3008
Image Processor

3016
Data Transfer
Activation
Switch

3015
Data Transfer
Mechanism

HOST

3000

FIG. 53B3

329/385

fixed focal length /
variable focal distance

3023

3035

3024A

3027

1867

3026B

3027

1861

3022

3031

3034

Camera Control Computer

3029

LCD Panel

3030

Touch Keypad

3032

Display Panel Driver

Keypad Driver

3033

Data Buffer

Image Processing Computer

3024

3025

3028

Data Transfer Activation Switch

3037

Data Transfer Mechanism

Host

3036

3026

Auto / Passive object detection
Using CCD array

FIG. 53B4

FIG. 53B5

330/385

fixed focal length /
variable focal distance

Auto/ BCD only, no object
detection

331/385

Variable focal length/
variable focal distance

3063
3062
3067
3066A
1862
3066B
3067
1861
3070
3072

18
18
18
LCD Panel
Touch Keypad

3061
3069
3062
3064
3071
3073

Camera Control Computer

Display Panel Driver
Keypad Driver

3065
Data Buffer
3068
Image Processing Computer

Manual Activation Trigger Switch
3074

Manual

FIG. 53C1

332/385

variable focal length / variable focal distance

3083

3087
3084

3082)

3086B
3087

186)

3095)

3094

IR Sensing Beam

IR-Based Object Detection Subsystem

Auto / IR object detection

3090

LCD Panel

3092

Touch Keypad

3091

Display Panel Driver

Keypad Driver

3093

3088E

Camera Control Computer

3089

308i

3085

3098

Data Buffer

Image Memory Buffer

Host

3096

Data Transfer Activation Switch

Data Transfer Mechanism

3097

18

18

18

FIG. 53C2

2080

333/385

variable focal length /
variable focal distance

Auto/Laser object detection

LCD
Panel

Touch
Keypad

Display
Panel
Driver

Keypad
Driver

FIG. 53C3

334/385

Variable focal Lngth/
variable focal distance

Auto/passive object detection
using ccd array

4023 4035

4027
4026A
862
4026B
4027
861

4030

4025

18

18

4031

LCD
Panel

Touch
Keypad

Camera Control
Engine

4029

Display
Panel
Driver

Keypad
Driver

4032

4033

Event
Timer

4024

4034

Data
Buffer

Image
Memory
Storage

4021

4028

Host

Data Transfer
Activation
Switch

Data
Transfer
Mechanism

4036

4037

4020

F/G.53C4

335/385

Variable focal length/
Variable focal distance

4047
4046A
1862
4046B
4047
4055
1861

4044D
4050
4052

4051

Master Control Engine
4049
4041
4045
4048
4040

Data Rate

Image Processor Complex

LCD Panel

Touch Keypad

Display Panel Driver

Keypad Driver
4053

Data Transfer Activation Switch
4057

Data Transfer Mechanism
4056

Host

Auto (BCD only, no object detection)

FIG.53C5

FIG.54A

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4076A

4079

4080B

4082

4066

4083

4081B

4077

4075

4078 4082

4063

4080A 4081A

4063

4083

4062

4076B

4064

FIG. 54B

(dual mirrors)

Fig. 1I5A-5P'

FIG. 55A

4105A

4096

4108

4106

4110B

4112

4111

4109B

4104

410A

4107 4112 4109A 4111

4092

4105B

4094

FIG. 55B

Bragg cell
Fig. 1I6A-6B

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FIG. 56A

4120

PLIB (4123)

3D FOV (4125)'

4124

4127

4128

4126

4122

4129

4130

4121

4131

4132

4133

Data Comm. Link

Host Computer/Network

341/385

FIG. 56B

DM

fig. 1I 7A - 7C

342/385

PLIB (4153)

3D FOV (4155)

4150

4158

4157

4154

4156

4152

4159

4160

4151

4161

4162
Data Comm.
Link

4163
Host Computer/Network

FIG. 57A

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4165A

4167 4168 4070B

4156 4172 471

4166 4169B

4152

4164

4070A 4169A 471 4172

4165B

4154

FIG. 57B

phase only LCd
PM panel
Figs 1F 8F-8G

PLIB (4183)

3D FOV (4185)

4187

4188

4184

4186

4182

4181a

4190

4189

4181

4191

Data Comm.
Link

4193

Host Computer/Network

4192

FIG. 58A

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4195A

4198

4196

4200B

4202 4201

4186

4197B

4197

4182

4194

4202

4200A

4201

4199A

4195B

4184

FIG. 58B

H5 optical shutter
fy. 1F 14A~14B

346/385

PLIB (4213)

3D FoV (4215)

4217

4218

4214

4216

4212

4219

4210

4220

4211

4221

Data Comm. Link

4223 Host Computer/Network

4222

FIG. 59A

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FIG. 59B

MCLD
Fig. IⅡ 15 A — 15B

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PLIB (4243)

3D FoV (4245)

4247

4248

4244

4246

4242

4249

4250

4241

4251

4252

Data Comm. Link

4253

Host Computer/Network

4240 →

FIG. 60A

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4255A

425.7 4258

4246

4256

4260B 4261

4259B

4261

4254

4262

4260A

4259A

4261

4242

4255B

4244

FIG. 60B

BAhalon (Tang. phase mod.)

Fig. 1 I 17A - 17B

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PLIB (4293)

3D FoV (4295)

4217

4298

4294

4296

4292

4274

4270

4299

4300

4277

4301

Data Comm. Link

4303
Host Computer/Network

4302

FIG. 61A

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METROLOGIC™

4305A

4296

4307 4308
4310B

4305

4309B
4311

4304

4312

4312

4310A

4309A
4311

4305B

4294

4292

FIG. 61B

mod. mapping
fig. LI 19A-19B

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PLIB (4323)

3D FoV (4325)

4328

4327

4324

4326

4322

4329

4320

4330

4321

4331

4332

Data Comm. Link 4333

Host Computer/network

FIG. 62A

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METROLOGIC™

4335A

4337   4338

4336

4326   4340B   4342

4339B

4334

4340A   4342

4339A

4341

4341

4322

4335B

4324

FIG. 62B

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PLIB (4353)

3D FoV (4355)

4357

4358

4354

4356

4352

4350

4359

4360

4351

4361

Data Comm. Link

4363

Host Computer/Network

4362

FIG. 63A

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4365A

4367
4368
4371B
4356
4370
4366
4369B

4352

4364
4371A
4370
4369A
4372

4365B

4354

FIG. 63B

ED or
mechanical Rotating Iris

Fig. 23A - 23B

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PIB (4383)

3D Fov (4385)

4388.

4387

4384

4386

4382

4380

4389

4390

4381

4391

Data Comm.
Link

4393

Host Computer/network

4392

FIG. 64A

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METROLOGIC™

4395A

4398

4397

4386

4401 B

4400

4396

4399B

4394

4400

4402

4401A

4399A

4382

4395B

4384

FIG. 64B

※ E-optical
Shutter Before
IP Lens
Fig. 1I24A

FIG. 67A

FIG. 67B

FIG. 67C

FIG. 65B

FIG. 65A

FIG. 66B

FIG. 66A

FIG 68.

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FIG. 68A

FIG. 68B

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3013
Data Input Points For
Object Identification Data

3000

LCD (3007)

Keypad (3009)

3014
Data Input
Points For
Object
Attribute
Data

"Object Identification
And Attribute
Information Tracking
And Linking
Computer"

120V

3015
(Output)
Network
Connection

2639

FIG. 68C1

µP

3016

H.D.

3006

RAM

ROM

2639

3001

3003

3004

3005

System Bus

3002

(Output)
Network Connection
(3015)

3008

3010

3012

I

I

I/O

LCD

Keypad

Network
Controller

HUB

3007

3009

3011

3017

Object Identification
Data Inputs
(3013)

Object Attribute
Data Inputs
(3014)

FIG. 68C2

Object Identification And Attribute Information Tracking And Linking Computer System.

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2639

3022

PID Element
Symbolically Linked to
Passenger Attribute
Data Element No. 1...
Passenger Attribute
Data
Element No. N

Data Element
Queuing, Handling, and
Processing and Linking
Mechanism

I/O
Unit

127

3020

Passenger
Identification
Data Inputs
(e.g. Bar Code
Reader, OCR
Imager RFID
Reader)

3021

Passenger
Attribute
Data Inputs,
(e.g
Passenger
Dimensions,
Weight,
X-ray analysis,
QRA, etc.)

FIG. 68C3

Data Element Queuing, Handling, and Processing Subsystem Employed In The Object Identification And Attribute Acquisition System Of The Present Invention. (131)

BID Element Symbolically Linked to Baggage Attribute Data Element No. 1... Baggage Attribute Data Element No. N

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Data Element Queuing, Handling, and Processing and Linking Mechanism

I/O Unit

127

Baggage Identification Data Inputs (e.g. Bar Code Reader, RFID Reader)

Baggage Attribute Data Inputs, (e.g Baggage Dimensions, Weight, X-ray analysis, Neutron Beam, Analysis, etc.)

FIG. 68C4

A	Each passenger who is about to board an aircraft at an airport, would first go to check-in station with personal identification (e.g. passport, drivers license, national identification card, etc.) in hand, as well as with articles of baggage to be carried on board the aircraft by the passenger.
B	Upon checking in with this station, the Passenger Identification (PID) Bar Code Symbol And Baggage Identification (BID) Bar Code Symbol Dispensing Subsystem issues (1) a passenger identification bracelet bearing (or otherwise encoded with) a PID bar code symbol, and (2) a corresponding PID bar code symbol for attachment to each package carried on the aircraft by the passenger. At the same time, this subsystem creates, for each passenger and set of baggage checked into the system at the check-in station, a passenger/baggage information record in the Passenger and Baggage Attribute RDBMS.
C	The passenger identification (PID) bracelet (or identification badge) is affixed to the passenger s person at the passenger check-in station which is to be worn during the entire duration of the passenger s scheduled flight.
D	The PLIIM-Based Passenger Identification And Profiling Camera Subsystem at the passenger check-in station automatically captures (i) a digital image of the passenger s face, head and upper body, (ii) a digital profile of his or her face and head (and possibly body) using the LDIP subsystem employed therein, and (iii) a digital image of the passenger s identification card(s). Other biometric information acquisition devices provided at the passenger check-in station can be used to acquire, from each passenger checking-in, passenger attribute information (e.g. retinal pattern information, fingerprint pattern information, voice pattern information, facial pattern information, DNA pattern information) to assist in the reliable identification of the passenger.
E	Each item of passenger attribute information acquired at the passenger check-in station is co-indexed with the corresponding passenger identification (PID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.

FIG. 68D1

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F	Each BID bar coded article of baggage is conveyed through the tunnel-type package identification, dimensioning and tracking subsystem installed before the entry port of the X-radiation baggage scanning subsystem (or integrated therewithin), and is then conveyed through the X-radiation baggage scanning subsystem. As this scanning process occurs, each bar coded article of baggage is automatically identified, imaged, and dimensioned/profiled by package identification, dimensioning and tracking subsystem and then imaged by x-radiation scanning subsystem.

G	Each item of baggage attribute information acquired at the baggage check-in station is co-indexed with the corresponding baggage identification (BID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.

H	Each BID bar coded article of baggage is conveyed through a second tunnel-type package identification, dimensioning and tracking subsystem installed downstream, before the entry port of the automated explosive detection subsystem EDS (or integrated therewithin), and is then conveyed through the EDS.

I	At the EDS station, each bar coded article of baggage is automatically identified, imaged, and dimensioned/profiled by package identification, dimensioning and tracking subsystem and then analyzed by EDS.

J	Each item of baggage attribute information acquired at the EDS station is co-indexed with the corresponding baggage identification (BID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.

FIG.68D2

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K — Conventional methods of detecting suspicious conditions revealed by x-ray images of baggage can be used (e.g. using an x-ray image monitor adjacent the x-ray scanning subsystem)

L — Intelligent information processing algorithms can be used to automatically operate on each passenger and baggage attribute record stored in the Passenger and Baggage Attribute RDBMS

M — Passenger attribute information stored in remote intelligence RDBMSs can be accessed and used with passenger and baggage attribute information in the Passenger and Baggage Attribute RDBMS in order to detect any suspicious conditions which may given concern or alarm about either a particular passenger or article of baggage presenting concern or a breach of security.

N — Such post-check-in information processing operations can also be carried out on passenger and/or baggage attribute information stored in the Passenger and Attribute RDBMS and/or in remote intelligence RDBMSs on a wide area network (WAN) or local area network (LAN) with human assistance, if necessary, to determine if a breach of security appears to have occurred.

O — If a breach is determined prior to flight-time, then the flight related to the suspect passenger and/or baggage might be aborted with the use of security personnel signaled by subsystem. If a breach is detected after an aircraft has lifted off, then the flight crew and pilot can be informed by radio communication of the detected security concern.

FIG.68D3

FIG. 69A

A — Each passenger who is about to board an aircraft at an airport, would first go to check-in station with personal identification (e.g. passport, drivers license, national identification card, etc.) in hand, as well as with articles of baggage to be carried on board the aircraft by the passenger.

B — Upon checking in with this station, the Passenger Identification (PID) Bar Code Symbol And Baggage Identification (BID) Bar Code Symbol Dispensing Subsystem issues (1) a passenger identification bracelet bearing (or otherwise encoded with) a PID bar code symbol, and (2) a corresponding PID bar code symbol for attachment to each package carried on the aircraft by the passenger. At the same time, this subsystem creates, for each passenger and set of baggage checked into the system at the check-in station, a passenger/baggage information record in the Passenger and Baggage Attribute RDBMS.

C — The passenger identification (PID) bracelet (or identification badge) is affixed to the passenger s person at the passenger check-in station which is to be worn during the entire duration of the passenger s scheduled flight.

D — The PLIIM-Based Passenger Identification And Profiling Camera Subsystem at the passenger check-in station automatically captures (i) a digital image of the passenger s face, head and upper body, (ii) a digital profile of his or her face and head (and possibly body) using the LDIP subsystem employed therein, and (iii) a digital image of the passenger s identification card(s). Other biometric information acquisition devices provided at the passenger check-in station can be used to acquire, from each passenger checking-in, passenger attribute information (e.g. retinal pattern information, fingerprint pattern information, voice pattern information, facial pattern information, DNA pattern information) to assist in the reliable identification of the passenger.

E — Each item of passenger attribute information acquired at the passenger check-in station is co-indexed with the corresponding passenger identification (PID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.

FIG. 69B1

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F	Each BID bar coded article of baggage is conveyed through the tunnel-type package identification, dimensioning and tracking subsystem installed before the entry port of the X-radiation baggage scanning subsystem (or integrated therewithin), and is then conveyed through the X-radiation baggage scanning subsystem. As this scanning process occurs, each bar coded article of baggage is automatically identified, imaged, and dimensioned/profiled by package identification, dimensioning and tracking subsystem and then imaged by x-radiation scanning subsystem.
G	Each item of baggage attribute information acquired at the baggage check-in station is co-indexed with the corresponding baggage identification (BID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.
H	Each BID bar coded article of baggage is conveyed through a second tunnel-type package identification, dimensioning and tracking subsystem installed downstream, before the entry port of the automated explosive detection subsystem EDS (or integrated therewithin), and is then conveyed through the EDS.
I	At the EDS station, each bar coded article of baggage is automatically identified, imaged, and dimensioned/profiled by package identification, dimensioning and tracking subsystem and then analyzed by EDS.
J	Each item of baggage attribute information acquired at the EDS station is co-indexed with the corresponding baggage identification (BID) number, and stored in the information records maintained in the Passenger and Baggage Attribute RDBMS, subsequent information processing.

FIG. 69B2

K — Conventional methods of detecting suspicious conditions revealed by x-ray images of baggage can be used (e.g. using an x-ray image monitor adjacent the x-ray scanning subsystem)

L — Intelligent information processing algorithms can be used to automatically operate on each passenger and baggage attribute record stored in the Passenger and Baggage Attribute RDBMS

M — Passenger attribute information stored in remote intelligence RDBMSs can be accessed and used with passenger and baggage attribute information in the Passenger and Baggage Attribute RDBMS in order to detect any suspicious conditions which may given concern or alarm about either a particular passenger or article of baggage presenting concern or a breach of security.

N — Such post-check-in information processing operations can also be carried out on passenger and/or baggage attribute information stored in the Passenger and Attribute RDBMS and/or in remote intelligence RDBMSs on a wide area network (WAN) or local area network (LAN) with human assistance, if necessary, to determine if a breach of security appears to have occurred.

O — If a breach is determined prior to flight-time, then the flight related to the suspect passenger and/or baggage might be aborted with the use of security personnel signaled by subsystem. If a breach is detected after an aircraft has lifted off, then the flight crew and pilot can be informed by radio communication of the detected security concern.

FIG. 69B3

372/385   X-Ray Scanner 2701   2709

120

2704   2708   2710   2710

2702   2705

2703

2700

FIG 70A

2710

2708   2909

120   X-Ray Scanner 2701

2706 (RFID-RFID (Reader)   Package   2710

2700

FIG. 70B

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2630

2631

Neutron
Beam
Scanner
2721

120

2724

2629

2631

2724

2722

2720

2723

FIG 71A

2630

2631

2629

120

Neutron
Beam
Scanner

RFID-Tag
Reader 2726

Package

2631

2720

FIG. 71B

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"Electromagnetic
Inspection
System "

2749

QRA-type
Scanning
tunnel
2741

120

2744

2748

2745

2742

2743

2740

FIG 72A

2749   2750

2748

2741

120

Package

RFID-tag
reader 2746

2750

2740

FIG. 72B

PFNA or QRA type Scanning Head

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2761

120A

2764

2760

120B

Container
ID No.

2768

2769

2770

2761

2770

2770

FIG. 73

2784

2780

120

2782A

2783

2782B

2-D
PLIIM-Based
CAT
Scanning
System

2786

2788

2787

3'

2785

2781

2785

FIG. 74

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2794   2792B

2790

120

120

2797

2796
2795

2793B

2799

2792A

2793A

2798

120

2794

optical encoder
and
unit translater

2793C

2791

3-D PLIIM-BASED
CAT Medical scanning
System

FIG. 75

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FIG. 76

2800

120
2803
2803
2802b
2802a
2809
121
2804
2802b
2805
2806
2807
2801

FIG. 77A

2810

"LCD viewfinder"
2816
2812
2811
2811
2817
2819

3-D "Hand-Supported
Mobile Digitizer"
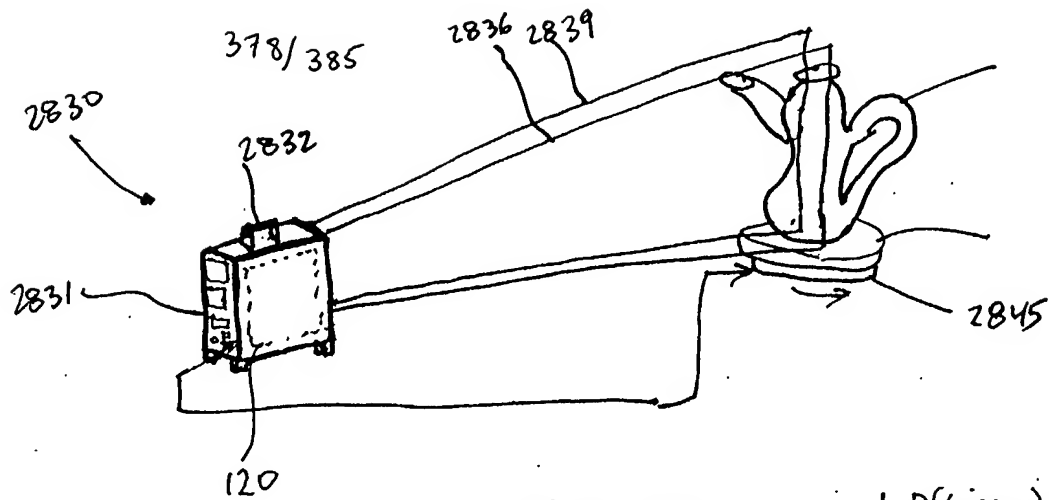2810

2820
2821
2822

FIG. 77B

2810
2815
2813B
2814
2813A
2811

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2830

2832

2836 2839

2831

120

FIG. 78A

1-D (Linear) sensor

2832

2835A

2837

2835B

2834

2830

2838

2831

FIG. 78B

2832

2830

2844

2834

LCD view finder 2840

keypad 2841

media (removable) 2842

2843

2846

FIG. 78C

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2850

2852

2851

2857

3-D Scan Field

2865

2855 (25", 122)

FIG. 79A

X-D (Area) sensor

2852

2856A

2858

2859

2850

2856B

FIG. 79B

2852

LCD view finder 2860

keypad 2861

media (removable) 2862

2863

2864

2866

2853

FIG. 79C

Automatic Vehicle Identification (AVI)
System of Present Invention

* Employing overhead profiling
and imaging during
License plate image capture

2870

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2876

2877

WAN

2874

2875

2873

LAN

120A

120B

Front
License
plate

2880

Rear
License
plate

Antenna
Beams
2878

PLIIB/FOV
2879

2872

Antenna
Beam
2882

PLIB/FOV
2883

Roadway
2871

FIG. 80.

Automatic Vehicle Identification (AVI)
System of Present Invention

* Employing overhead profiling
  and imaging techniques during
  License plate image capture

2898

2899

2897

2896

WAN

LAN

2895

120

Automatic PLAB/FW
Direction Switching
Unit
(28911)

2894

Optical
Path 2

2893

Optical Path 1

Am
Laser
Beams
(2910)

Traffic Direction

Roadway
(2892)

2890

FIG. 81A

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2891

540

2901

2907

120

2903

2906 2900

2904

position 2: imaging Rear of Automobile

position 1: imaging front of Automobile

FIG. 81B

120

2901

Automatic
PLIEB / FoV direction
switching unit

2906

2900

2891

2907

2904

2903

2908

AM Laser
Beams

2894

(2910)

optical Path1

optical Path 2

FIG. 81C

120

2904

Position 1

AM Laser Beams
2910

2903

Position 2

Optical Path 2

$\Delta T = X/V$
(switch at $t_1 + \Delta T$)

V(t)

Optical Path1

2894

t_1

x

t_2

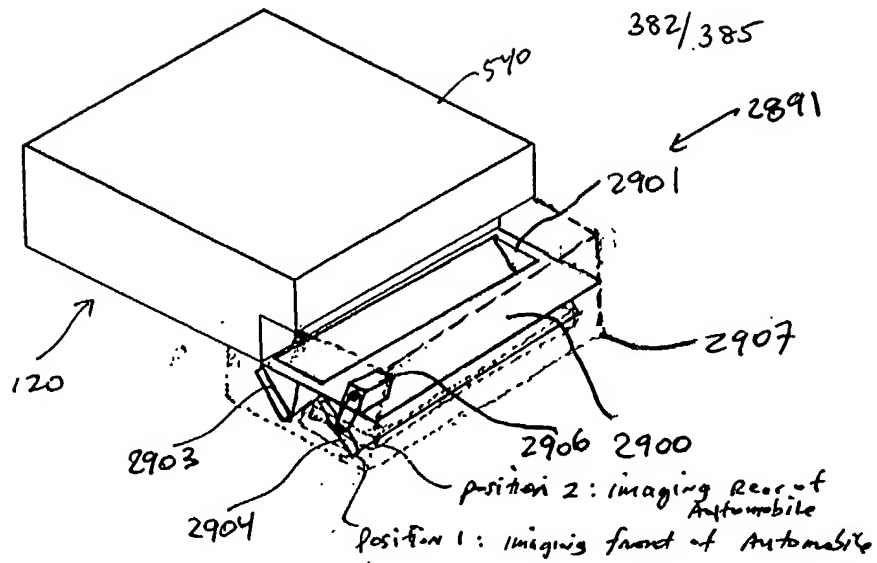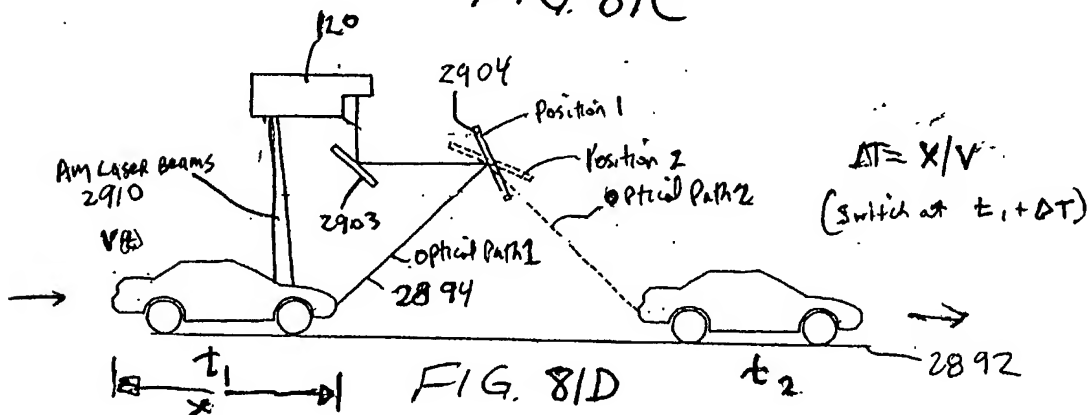2892

FIG. 81D

Automatic vehicle classification (AVC)
System of the Present Invention

2920

2927 WAN 2926

2925

2924

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LAN 2923

2929
120E

120D

2922

120A

2930

2931

2922

Balta Bas Truck Co.

120C 2932

BU1124 KY.

120B 2932

Roadway 2921

* Employing overhead and lateral
  profiling and imaging
  techniques

FIG. 82

Automatic Vehicle
Identification and
Classification (AVIC)
system of the
present invention

FIG. 83

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540

2951

2950

2952

UVGI
UNIT

120

UV Light Beam
at 253.7 nanometers

2950   2953

FIG. 84A

2954

2950

541A

541B

540

540

542

543

120

FIG. 84B